Getting from here to there: Boosting women's participation in bicycling through adult bicycle skills training

by

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Abstract

Increasing bicycling in cities is a public health and sustainability goal. Although supportive infrastructure is a necessary precondition for most people to begin riding, other forms of encouragement are also needed to spur uptake across populations. Women are an important target group as they participate in bicycling at roughly one-third the rate of men. While much is known on the importance of a safe, dense, and well-connected bikeway network, there are knowledge gaps on 'soft' interventions related to training or education. Questions remain on the effectiveness of bicycle skills training, how trainings interact with the bikeway network, and, given the bicycling gender disparity, the role training has on supporting women's participation. To address these gaps, this dissertation assessed the impact of a bicycle training course in encouraging participation among new and returning bicyclists, and the broader processes that enabled bicycling for women of diverse backgrounds. Weaving together behaviour change theory and gender frameworks, the longitudinal mixed methods study drew on questionnaire and interview data from Metro Vancouver, Canada—a region promoting bicycling and extending its bicycle infrastructure.

The dissertation found that training facilitated only modest short-term increases in leisure bicycling. Other elements of the social and physical environment did not support a full variety of journeys to be made by bicycle, and these elements were more influential than individual attributes such as skill or knowledge. Nevertheless, training provided a safe environment to improve handling skill, learn traffic rules and safety, or reinforce pre-existing knowledge. Training enabled some participants to bicycle in more challenging conditions, thus enhancing their bicycling mobility. Policy recommendations derived from this work include: bold expansion of the bikeway network; more intensive training and practice sessions for new and returning riders; broader outreach to clarify bicycling norms and etiquette; education for drivers; and integrating a gender lens into bicycle planning. By applying a novel integration of gender and social practice theoretical frameworks to examine the impact of an intervention on an under-studied population of new and returning bicyclists, this dissertation contributes both new evidence and new conceptual insights to theory and practice of bicycling in cities.

Keywords: bicycle; gender; Social Practice Theory; intervention; behaviour change; mixed methods

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Preface

This statement certifies that the work presented in this thesis was conceived, designed, and written by the candidate, Stephanie Sersli (SS). All research described in this dissertation was approved by the Simon Fraser University Office of Research Ethics (#2015s0220 and #201720653).

The scoping review presented in chapter 2 was designed, executed, and synthesized by SS with guidance from Dr. Megan Winters (MW) and data extraction assistance from Danielle DeVries (DD). The data and text was written as a manuscript and circulated to co-authors: MW, DD, Dr. Maya Gislason (MG), and Dr. Nicholas Scott (NS). A version of chapter 2 has been published as Open Access and is reused here as per Elsevier's Copyright and License rights for authors: Sersli S, DeVries D, Gislason M, Scott N, and Winters M. Changes in bicycling frequency in children and adults after bicycle skills training: a scoping review. Transportation Research Part A, 2019(123): 170-187. doi.org/10.1016/j.tra.2018.07.012

The data and text presented in chapters 3-5 were all written as manuscripts and circulated to co-authors: MW, MG (chapters 4 and 5 only), and NS. All co-authors made contributions in accordance with supervisory committee duties. For each analysis, SS was primarily responsible for the literature review, designing the study, and analyzing and interpreting the results, with substantive guidance and input from MW.

A version of chapter 3 has been published and is reused here as per Elsevier's Copyright and License rights for authors: Sersli S, Scott N, and Winters M. Effectiveness of a bicycle skills training intervention on increasing bicycling and confidence: a longitudinal quasi-experimental study. Journal of Transport & Health, 2019(14): 100577. doi.org/10.1016/j.jth.2019.100577

A version of chapter 4 is currently under review for peer-reviewed publication: Sersli S, Gislason M, Scott N, and Winters M. Easy as riding a bike? Bicycling competence as (re)learning to negotiate space.

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Chapter 1.

Introduction

1.1. Rationale

The UN (2009) has declared “climate change is one of the greatest challenges of our time”. Cities around the world are increasingly recognizing the importance of reducing car use and investing in cycling (Handy et al., 2014) as a carbon neutral, cost-efficient, space-efficient, and healthy form of transport and leisure (Götschi et al., 2016; Oja et al., 2011; Zahabi et al., 2016). Despite these benefits, the proportion of trips by bicycle in Canada is about 2 percent, which is similar to the US, Australia, and Britain, but substantially lower than in some European and Asian countries (Pucher and Buehler, 2008). Increasing the number of people using bicycles, especially for transport, has become a public health and sustainability goal. Many cities and regions have ambitious mode share goals; for example, that by 2040, 15% of all trips less than 8 km within Metro Vancouver be made by bicycle and 50% of all bicycling trips be made by women (Translink, 2011). To meet these goals, bicycling will need to be adopted broadly across the population. A challenge for planners is to identify and prioritize strategies that will increase bicycling (Handy et al., 2014). This dissertation is a study about one particular type of promotion activity—bicycle training courses—in encouraging participation among new and returning bicyclists, including women from diverse backgrounds.

1.2. Background

There has been substantial research in the past two decades on the determinants of urban bicycling. Bicycling is a complex behaviour, with barriers and facilitators operating at societal and personal levels. To increase urban bicycling, experts recommend implementing comprehensive packages of integrated and complementary interventions. Comprehensive packages target determinants at multiple levels (from societal to individual) through policies and environmental changes, to individual-level encouragement (Pucher et al., 2010). These might include policies restricting car use, providing a safe, dense, and well-connected bikeway network (bicycle facilities and

traffic-calmed streets) (Buehler and Dill, 2016), and promoting bicycling through programming interventions and behaviour change campaigns (Winters et al., 2017).

For many people, the largest barrier to urban bicycling is fear for safety related to sharing road space with motorized traffic (Heinen et al., 2010; Pucher et al., 2010). For both current and prospective bicyclists, volume, speed, and types of traffic on shared roads—as well as hostile behaviour from motorists—are concerns (Fishman et al., 2012). To address traffic safety concerns, experts have recommended on-road bicycle infrastructure, reductions in motor traffic speed, and motorist awareness campaigns (Fishman et al., 2012). Despite substantial evidence demonstrating that bicycling infrastructure and traffic calming are necessary preconditions to create conducive environments to urban bicycling (Nello-Deakin, 2020), many cities are still in the process of providing connected, high-quality bicycle infrastructure.

While improved bicycle facilities have been associated with increased ridership, these facilities have not necessarily been effective in increasing the diversity of ridership (Aldred et al., 2017; Pistoll and Goodman, 2014). There is growing concern that benefits derived from investment in bicycling infrastructure are unequally distributed across neighbourhoods (Braun et al., 2019) as well as by social group. In low-bicycling countries such as Canada, the US, and the UK, where bicycling is a marginalized travel mode, population-level analyses (e.g., using census data) routinely find bicycling disparities based on gender, age, and race (Aldred et al., 2017; Butler et al., 2007; Goodman and Aldred, 2018; Nehme et al., 2016; Porter et al., 2018, 2020; Winters et al., 2007). For example, in Canada, women use bicycles approximately a third as much as men, and this disparity is also seen in Australia, New Zealand, the UK, and the US (Garrard et al., 2012; Heesch et al., 2012; LeVine et al., 2014; Shaw et al., 2020).

While engineering changes improve safety conditions, programming interventions such as bicycle skills training can increase knowledge, skills, and confidence. The latter becomes especially important given the shortfall of dense, connected, quality infrastructure in most cities. Programming interventions are less expensive than engineering solutions and are more easily customized to meet the needs of specific groups (Kandt et al., 2015; Papagiannakis and Vitopoulou, 2015). Bicycle skills training courses are promoted as a cost-effective way to increase bicyclists' confidence, perceived safety, and awareness of traffic rules (Nachman and Rodríguez,

2019; Sherriff, 2014). Furthermore, training can promote the location of bicycle routes and bicycle-accessible destinations, thus improving people's perceptions of neighbourhood bikeability (Ma and Dill, 2017). Recent scholarship recommends conceptualizing current and prospective bicyclists as heterogenous groups with different needs (Damant-Sirois et al., 2014), and courses may be helpful to target underrepresented populations. Bicycling experience, and possibly sociodemographic characteristics, are thought to produce important differences in comfort level and infrastructural preferences (Ma and Dill, 2017; Thigpen, 2019). For example, less experienced bicyclists may be only willing to bicycle on very quiet routes, or may need additional supports to skill up or find appropriate routes for their comfort level.

1.3. Knowledge gaps

While much is known on the importance of a safe, dense, and well-connected bikeway network, there are still knowledge gaps on 'soft' interventions related to training or education. Questions remain on the effectiveness of bicycle skills training, how bicycle skills trainings interact with the bikeway network, and, given the bicycling gender gap, the role bicycle skills training has on supporting women's participation. I provide details on these gaps and why they matter in the subsections below.

1.3.1. Bicycling training courses

Despite broad enthusiasm for bicycle skills training, there are limited studies that have examined the impact of courses on adults (Johnson and Margolis, 2013; Pucher et al., 2010). Previous systematic reviews on varied interventions to increase bicycling found that bicycle skills training had mixed (i.e., positive and null) results on bicycling uptake (Stewart et al., 2015; Yang et al., 2010). Furthermore, the role of bicycle skills courses in causing modal shift is not well understood. The majority of studies on bicycle skills training are quantitative in design: they measure change, but offer limited understanding into why or why not change occurred. Importantly, studies on bicycle skills training typically analyse average change across all participants rather than investigating for whom the intervention may have been especially effective (Garrard, 2015). Studies often do not have enough data to analyse differences in subgroups. A different method to assessing the effectiveness of courses could adopt a theory-driven

approach. Theory-driven approaches strive to explicitly identify the assumed change processes underpinning course design, and can thus articulate hypotheses of how courses are expected to lead to change among different types of participants. Such approaches can provide insight into why and how interventions work in particular circumstances, and help clarify why different individuals respond to the same program differently (Funnell and Rogers, 2011).

Women have become an important target audience for bicycling promotion. Researchers suggest there is latent demand—that is, potential bicycling that is not being realized due to a variety of constraints—to substantially increase bicycling. Women make a number of short trips that are potentially feasible by bicycle (Mitra et al., 2016; Shaw et al., 2020), and encouraging mode shift could relieve traffic congestion and public transit demand. Despite the well-documented gender gap in everyday bicycling, studies suggest there is substantial appetite from women to start bicycling or to bicycle more often (Rissel et al., 2010; Sustrans, 2018).

Safety concerns regarding traffic and confidence are primary barriers to women's bicycling (see next section), which can be addressed by bicycle training courses. It is also possible that training begins to address issues of inclusivity by creating welcoming and nonjudgmental environments. No studies appear to have assessed this aspect of training; however, social and other media articles (Heing, 2019) routinely discuss how women can feel dismissed in bicycle culture and the subsequent importance of nonjudgmental learning environments. Studies have recommended bicycle courses to encourage women's participation (Bekkum et al., 2011; Handy, 2014; Lam, 2020), and early data from one monitoring report indicates training may narrow the gender gap in bicycling participation (Transport for London, 2016). Women participate in bicycling training courses more so than men (Sersli et al., 2019a), especially at the entry-level and intermediate level. However, there is little research that investigates the role of bicycle skills training to support women's bicycling participation. This requires developing a nuanced understanding of women's bicycling needs and aspirations—a challenging task given the diversity across women and the diverse contexts they inhabit.

1.3.2. Gender disparities in bicycling

Differences in bicycling between men and women are well-documented, with three primary overlapping explanations (Aldred et al., 2017; Xie and Spinney, 2018): first, safety concerns regarding traffic and personal safety pertaining to public space; second, men's and women's different trip characteristics and division of household labour; and third, cultural norms and meanings associated with bicycling. The extent to which various studies engage with the sociocultural processes accounting for differences between men and women tend to be differentiated by traditional disciplinary areas of inquiry (for example, studies in transportation planning versus sociology), and are likely limited by types of data analyzed (for example, secondary survey data). Gender is often understood in terms of a binary framing between men and women, without further interrogation into the forms of social organization that differentiate men and women (e.g., modes of production that shapes division of labour in households) leading to different outcomes (Sprague, 2016). Furthermore, men and women are often treated as homogenous categories, without delving into other forms of structural inequality—class, race, ability—that produce as many differences within groups as between groups. This can lead to gender normative research findings, which may consequently inform policy directions, where men and women are assumed to experience gender advantage or disadvantage uniformly.

The evidence summarized below illustrate a diversity of approaches to identifying and explaining gender differences in bicycling. This broad range of treatment of women's bicycling underscores the need for an interdisciplinary critical gender lens to account for the complexities and paradoxes of power (Carey et al., 2018). A critical gender lens draws from feminist and intersectional theorists (discussed in section 1.5.2) to understand difference and diversity while also grounded in concern for material inequities. It considers gender as a multilevel and complex structure.

1.3.2.1 Traffic safety concerns

Although traffic safety concerns pose the primary barrier to urban bicycling for most people in low-bicycling contexts (Aldred et al., 2017; Heesch et al., 2012), women are less inclined than men to ride on streets without bicycle-specific infrastructure or separation from traffic (Aldred et al., 2016; Teschke et al., 2017). There has been a tendency in the transport literature to account for these patterns as natural differences

(i.e., women are more risk averse) (Bonham et al., 2015), but research going forward is encouraged to probe underlying gendering processes (Ravensbergen et al., 2019). For example, when compared to men, women tend to remain novice or occasional bicyclists (Daley et al., 2007). This has implications for comfort level bicycling in mixed traffic. Much of what we know about bicycling differences between men and women is from cross-sectional questionnaires which are unable to reveal gendering processes—that is, the social process of becoming man/masculine or woman/feminine (Bonham et al., 2015).

1.3.2.2 Personal safety concerns

Personal safety concerns, specifically sexual harassment from men, is known to shape women's mobility in cities (Law, 1999; Loukaitou-Sideris, 2016). Given the prominence of personal safety concerns in the gender and mobility literature, it is somewhat surprising this issue has not garnered more attention pertaining to bicycling. Urban bicycling occurs in public space, but women may be deterred from environments that reduce feelings of personal safety (such as poorly lit or isolated locations) (Xie and Spinney, 2018). Alternately, they may feel more comfortable travelling by bicycle than foot.

1.3.2.3 Trip characteristics

Women's responsibility for childcare and household labour is thought to contribute to the bicycling gender gap. Across European countries, those with greater gender equality tended to have a greater percentage of women bicycling (Prati, 2018). The trend was especially pronounced when examining gender gaps in time spent on caring, cooking, and housework. Surprisingly few studies have examined the effect of household composition on men's and women's bicycling, despite evidence that having children in the household may be a greater constraint on women's bicycling than men's (Grudgings et al., 2018; Heesch et al., 2012; LeVine et al., 2014). I am aware of only two studies (Bonham and Wilson, 2012a; Eyer and Ferreira, 2015) that explicitly consider women's experience of bicycling with children. Only one study, in a Dutch setting with immigrant women who did not know how to bicycle, has reported on how bicycle skills training might enable women to accomplish bicycle journeys pertaining to household labour (van der Kloof et al., 2014).

1.3.2.4 Cultural norms and meanings pertaining to the bicycle

In low-bicycling countries, bicycling is associated with sport or high risk tolerance (Aldred, 2013; Daley and Rissel, 2011). The first, sport bicycling, is synonymous with speed, competition, and risk (Albert, 1999; Fullagar and Pavlidis, 2012; Prati et al., 2019)—what Barrie et al. (2019, p. 116) call "cycling masculinities". The second, high risk tolerance is further underscored by the decades-long dominance of the vehicular bicycling paradigm that encouraged speed, efficiency, and assertively claiming the road (McCullough et al., 2019). Together, these cultures have fostered an image of urban bicycling that it is for sporty, highly skilled, or courageous people—an image that has a distinctly gendered and classed appeal (Lam, 2017; Psarikidou, 2020; Steinbach et al., 2011).

While there are studies that have examined how meanings shape women's bicycling decisions, we know little about if or how bicycle skills training empower women to negotiate these meanings in new ways. However, previous studies provide valuable insights about how to proceed with such an analysis. For example, Steinbach et al. (2011) draw on Bourdieu to understand why some bicycling practices were more readily available to particular groups of women. Fullagar and Pavlidis (2012) advocate using an explicit gender lens to ensure analyses of power remain foregrounded. Heim LaFrombois (2019) uses a feminist geography lens to frame public space as a site of social and power relations.

1.4. Thesis aims and objectives

1.4.1. Addressing knowledge gaps

In summary, cities seek to increase bicycling, and women are an important target population. Figure 1.1 illustrates the overlap of three broad areas discussed above: strategies to increase bicycling, bicycle training courses, and bicycling gender disparity. Figure 1.1 also shows, very broadly, the gaps discussed in section 1.2: although bicycle training courses comprise one aspect of a comprehensive package to promote bicycling, there is little evidence to show their effectiveness in this regard; it is also poorly understood how courses may address disparities in bicycling and facilitate women's participation.

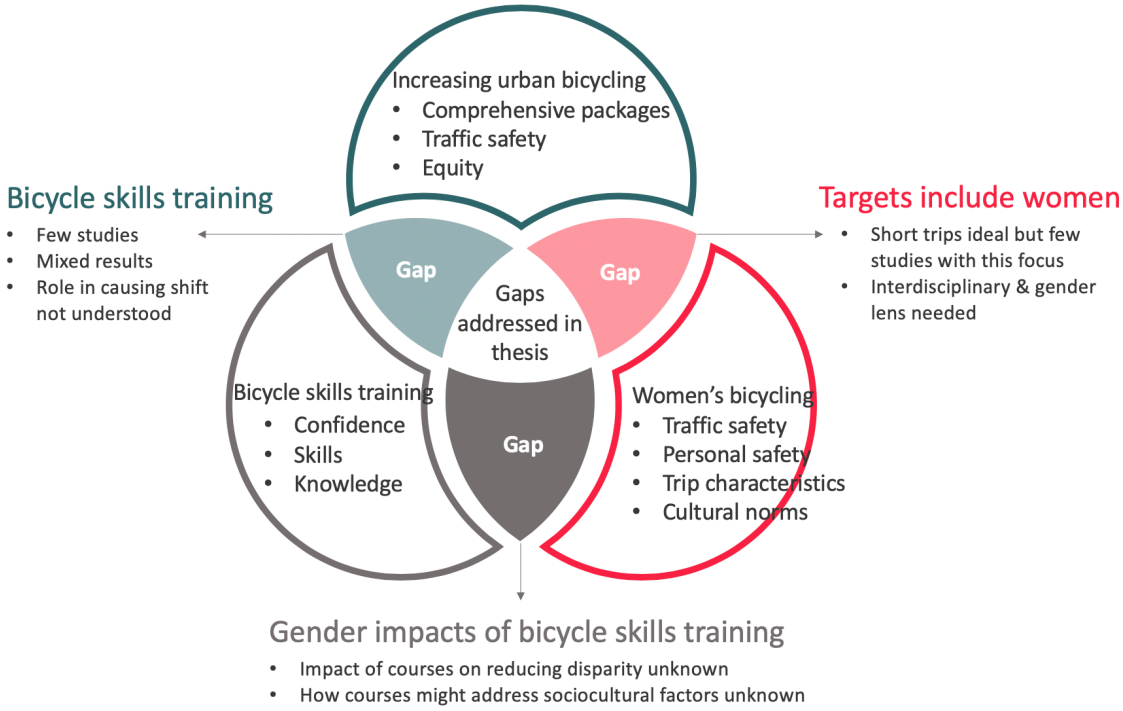

Figure 1.1 Research gaps addressed by dissertation

In this thesis I aimed to address gaps in data and knowledge on the impact of bicycle skills training, drawing on mixed methods to: i) map evidence of bicycle skills training on increasing bicycling; ii) measure the impact of bicycle skills training on bicycling and confidence; iii) understand how bicycle skills training support women's bicycling participation; and vi) identify broader contextual processes that enable bicycling for women of diverse backgrounds, before and after participating in a bicycling training course.

1.4.2. Specific objectives

This thesis assessed the impact of a bicycle training course in encouraging bicycle participation among new and returning bicyclists, including women from diverse backgrounds. Chapters are organized around each of the following four specific objectives:

- Identify and describe evidence on changes in bicycling frequency associated with bicycle courses
- Compare changes over one year in bicycling (commuting, errands, leisure) and confidence, between course participants and a comparison group

- Examine the impact of a course among women living in Vancouver, an urban environment that has been extending its bicycle infrastructure
- Describe how women begin or maintain bicycling during and following the time they have children living at home.

1.5. Theoretical frameworks

This dissertation is concerned with the impact of bicycling skills training courses on bicycling participation, and the broader processes that enable bicycling for women of diverse backgrounds before and after participating in a course. Behaviour change frameworks and consequent intervention assessments provide the foundation for empirical analysis in later chapters. There are multiple explanations of how behaviour arises and how to encourage shifts, and this section briefly introduces the frameworks that will be used in this dissertation.

Given gender disparities in bicycling, this dissertation also adopts a critical gender lens to understand how effective the intervention was for women, used in chapters 4 and 5. Pederson et al. (2015) argue that uncritical assumptions about gender can reinforce harmful stereotypes that undermine the effectiveness of health promotion (and interventions) and perpetuate gender inequities. Instead, they argue for an approach that considers gender "as an element of social systems and structures, not merely an individual attribute" (Pederson et al., 2015, p. 146). This section introduces the definition of gender used in the dissertation, and the underlying body of work that informs it.

1.5.1. Behaviour change frameworks

Behaviour is complex and influenced by a range of determinants at the personal and structural level. Much health promotion is influenced by theory that focuses on personal (i.e., individual level) attributes rather than structural (i.e., broader social and environmental) drivers (Glanz and Bishop, 2010). Thus, despite the widespread adoption of social ecological frameworks that recognize multiple levels of influence, the structural aspects that shape each level of influence are often left undertheorized (Burke et al., 2009; Hawe et al., 2009). Consequently, public health scholars argue that too many health behaviour interventions attend to individual-level factors and are grounded in individualist approaches, and that corrective action must take into account contextual

issues and social structures as well as the interplay between the individual and the structural (Baum and Fisher, 2014; Hawe, 2015a; Holman et al., 2017). In the past decade these and other scholars have highlighted the importance of explicitly defining the programme theory underpinning interventions, hypothesizing how intervention and context interact, and the challenges of defining, measuring, and articulating the role of context (Coles et al., 2017; Davidoff et al., 2015; Howarth et al., 2016; Shareck et al., 2014; Squires et al., 2015). Two behaviour change frameworks which integrate elements of individual-level factors and contextual influence are the Behaviour Change Wheel System and Social Practice Theory (Niedderer et al., 2014).

1.5.1.1 Behaviour Change Wheel System

The Behaviour Change Wheel System in an integrative cross-theoretical approach consisting of three linked tools: the Theoretical Domains Framework, the Behaviour Change Wheel, and a taxonomy of behaviour change techniques. The Behaviour Change Wheel system has been used to identify behavioural barriers and facilitators and hence inform intervention design (Debono et al., 2017; Newlands et al., 2016; Ojo et al., 2019; Thompson et al., 2018), as well as to integrate findings of systematic reviews (Currie et al., 2013; Hynynen et al., 2016; McParland et al., 2018; Staddon et al., 2016).

The Theoretical Domains Framework was developed to synthesize overlapping theories of behaviour change. Its authors reviewed dozens of theoretical constructs from various behaviour change theories and sorted the constructs into 14 domains (Cane et al., 2012). Of the 14 domains, 3 explicitly relate to contextual determinants of behaviour (Nilsen and Bernhardsson, 2019). The Theoretical Domains Framework was then further distilled into just three overarching conditions proposed to elicit behaviour change: capability, opportunity and motivation, known as COM-B. COM-B conceptualizes human behavior (B) as resulting from interaction between physical and psychological capabilities (C), opportunities provided by the physical and social environment (O), and reflective and automatic motivation (M).

To link determinants of behaviour (Theoretical Domains Framework and the subsequent COM-B) with appropriate interventions and policies, the authors created a Behaviour Change Wheel. The wheel consists of three components. The first component is COM-B. The second component of the wheel are nine intervention functions

(education, persuasion, incentivization, coercion, training, restrictions, environmental restructuring, modelling, and enablement). Each intervention function targets one or more of the COM-B conditions (i.e., capability, opportunity, or motivation). The third component of the wheel are seven policy levers (fiscal measures, guidelines, environmental/social planning, communication/marketing, legislation, service provision, regulation) that suggest how the intervention can be supported or enacted (Michie and West, 2013). These policy levers are community-level (e.g., workplace) or population-level (e.g., government) strategies (Michie and West, 2013).

To describe the content of interventions in greater detail, the authors of the Theoretical Domains Framework also created a taxonomy of 93 behaviour change techniques. Each behaviour change technique can be mapped to one or more of the nine intervention functions in the Behaviour Change Wheel (Michie et al., 2013). While the Behaviour Change Wheel provides a systematic process for compiling crucial intervention components and does so in a logical sequence (Hansen et al., 2017), the use of the behaviour change taxonomy enables more consistent reporting which may enable synthesis, comparison, and replication of interventions.

1.5.1.2 Social Practice Theory

Social Practice Theory (SPT) reorients the focus of behavioural inquiry away from individual psychological attributes toward a greater emphasis on social context and conventions. To underscore the extent to which socialization shapes human action, social practice theorists refer to behaviour as practice. Rather than the individual being the unit of analysis, in SPT the focus is on the practice itself, with individuals being the carriers of practices (Reckwitz, 2002). Practices are enacted at different scales, e.g., of household, institution, and society (Shove et al., 2012). SPT conceptualizes practices as routine and habitual, integrated with other daily practices, and contingent on structural factors that make certain practices more feasible than others (Kurz et al., 2015). By bridging the interaction between everyday action (microlevel) and structural processes (macrolevel), SPT enables researchers to explain descriptive accounts of everyday action with critical analysis of broader social processes.

SPT comprises a body of concepts from various theorists (Halkier and Jensen, 2011; Maller, 2015). Shove and colleagues (2012) have incorporated these various strands in a streamlined model, where practices are comprised of three interdependent

elements: competences (skills, know-how); materials (physical resources); and meanings (values, sociocultural significance, embodied understandings of the situation). For example, the practice of bicycle commuting might include competences of fitness and navigation; materials of a bicycle and infrastructure; and meanings of bicycle commuting as a healthy activity (Larsen, 2016; Spotswood et al., 2015). Practices emerge, morph, or cease as the links between elements (materials, skills and images) are created, maintained, or broken (Shove et al., 2012). The configuration of these elements result in variation in practices across people, as well as across time and place (Hui, 2017).

People can be recruited to or defect from practices. Understanding recruitment is central to promote desired practices, such as cities' desire to increase urban bicycling. Examining recruitment can also reveal power dynamics. Blue et al. (2016) suggest that the likelihood of being recruited to a practice is contingent upon "what the practice itself demands and on previous life histories and resources (in terms of know-how, material elements, etc) accumulated along the way" (p. 44). Thus recruitment is also closely linked to inclusion in terms of access and participation opportunities. Some practices will be inaccessible for some people because of an unequal distribution of materials, opportunities to develop competences, or negative meanings (Meier et al., 2018).

Practices are almost always woven together ("bundled") with other aspects of daily life (Shove et al., 2012). Some examples from the practice of driving illustrate how practices bundle. One reason people take the car to work is because driving makes it easier to combine commuting with practices of leisure, healthcare or shopping (Cass and Faulconbridge, 2016). Some practices bundle more tightly, loosely, or not at all based on their temporal and spatial aspects (Cass and Faulconbridge, 2016; Shove et al., 2012; Watson, 2012). Supermarkets located on arterial roads with ample parking facilitates the connection of stopping for groceries on the drive home from work. Practices also bundle on the compatibility of their elements, particularly if they share an element. Practices can compete for resources, such as people's time and energy, but practices can also support each other (Blue et al., 2016). Examining practices where they intersect with other practices provides additional explanatory power for why some practices—such as driving to work—are difficult to shift. Practices that intersect with other commitments, obligations, or that require the participation of other people tend to be difficult to shift (Southerton, 2006).

Understanding how people are recruited to practices, how practices are embedded within practice bundles, and how that embeddedness enables repeated enactment of the practice can inform intervention design (Spotswood et al., 2019, 2017). An SPT lens can provide opportunities to "peer inside the black box of why interventions are (in)effective and thus whether they will continue to be (in)effective when implemented in different places and times" (Meier et al., 2018, p. 210). The nascent body of literature on designing SPT-informed interventions is limited with few empirical examples (Spotswood et al., 2019; Welch, 2016). However, SPT has been used to conceptualize policy interventions to change mobility practices (Spurling and McMeekin, 2015).

1.5.2. Gender

This dissertation uses the Canadian Institute of Health Research's definition of gender:

> Gender refers to the socially constructed roles, behaviours, expressions and identities of girls, women, boys, men, and gender diverse people. It influences how people perceive themselves and each other, how they act and interact, and the distribution of power and resources in society. Gender identity is not confined to a binary (girl/woman, boy/man) nor is it static; it exists along a continuum and can change over time. There is considerable diversity in how individuals and groups understand, experience and express gender through the roles they take on, the expectations placed on them, relations with others and the complex ways that gender is institutionalized in society. (Canadian Institutes of Health Research, 2020)

Among the ample theoretical treatments of gender, we find Connell's relational gender theory (Connell, 2012) helpful as it is an integrative approach that emphasizes how gender operates from the level of individual gendered selves to the organization of institutional domains. Relational gender theory, explicitly concerned with structure and practice, conceptualizes gender as multidimensional and constituted by four interwoven analytic strands. The four strands—power, production, cathexis, and symbolic relations—form large-scale patterns, determining everyday social practices in which gender is enacted (Connell and Pearse, 2014). Power relations include violence against women, institutionalized gender biases, and Foucauldian micropower. Production relations refer to the gender division of labour within and outside of households. Cathexis pertains to emotional commitments and attachments. Symbolic relations are

the meanings that operate, for example, in sport, dress, and gesture. These four analytic strands—particularly production and symbolic relations— provide potential entry points to examine gender disparities in bicycling. Relational gender theory incorporates important theoretical concepts of performativity, embodiment, and intersectionality.

1.5.2.1 Femininities and masculinities

The most well-cited aspect of Connell's work is the concept of gender hegemony, which highlights how power operates through gender hierarchies. Masculinities and femininities are social norms about men's and women's behaviour. Though there are diverse and multiple forms of masculinity and femininity, dominant masculinity subjugates all femininities, as well as by subordinating other masculinities. Hegemony is achieved through valorization of certain ideals, the devaluation of femininity, and the consent or participation of subaltern groups. Importantly, masculinities and femininities are negotiated and shift over time and context (Connell and Messerschmidt, 2005). In summary, gender is relational. Gender practices and characteristics do not exist in isolation, but are constructed and defined in relation to one another, typically as opposites (Lyons, 2009).

1.5.2.2 Gender as practice

Gender is not something that we have or are, but something we do. The term 'doing gender' describes how, through daily interactions, people enact normative gender behaviour and are held accountable by others to those norms (West and Zimmerman, 1987). Butler (1990) theorized that gender, understood as masculine or feminine, is performed. Gender performance refers to the repeated enactment of the appropriate masculine or feminine manner, whereby it becomes is an unconscious performance that mirrors gender norms. By contrast, performativity involves conscious decision-making to adhere to or resist gender norms (Tredway, 2018). Similar to the concept of gender performance and performativity is that of 'practicing gender' which is done both unconsciously and intentionally (Yancey Martin, 2003). Practicing gender is acquired through repetition, which helps explain why practicing masculinity may be more available to men/boys than women/girls. However, it is not necessarily women that do femininity or men masculinity, but that what is considered masculine or feminine can vary by context, profession, time, or space (Collins and Bilge, 2020; Nentwich and Kelan, 2014; Schippers, 2007; Watson, 2018).

1.5.2.3 Embodiment and space

Bodies and gender are mutually constituted, meaning that masculine and feminine ideals influence how people use their bodies, which in turn shape masculinities and femininities (Lyons, 2009). It is through repeated practice that gender becomes embodied and naturalized, whereby the association between gender performance and a sexed body become invisible and assumed as natural and essential (Tredway, 2018). Masculinities and femininities are constructed through gestures, postures, and movements. Masculine embodiment is conceptualized as "demanding bodily competence, control of self and others, and a certain unself-conscious ease" whereas feminine embodiment "manifests as self-consciousness: a constant awareness of the body as vulnerable, as an object of desire (or of violence)" (Mason, 2018, p. 96). In developing a theory of gendered bodily comportment, Young (2005) argued that girls are discouraged from using their bodies freely and fully, and are not taught to take up, use, or move through space with confidence. By contrast, sociologists illustrate the role of sport and masculinity, where men are encouraged to use their bodies to take up space and dominate (Maclean, 2019; Wellard, 2016). Thus, feminine bodily inhibition is learned and cultivated, just as masculine bodily ease. Feminine and masculine embodiment will vary across women and men based on factors including class, race, age, and one's exposure to different activities or trainings (Maclean, 2019).

1.5.2.4 Intersectionality

Gender and embodiment theory has been greatly enriched by intersectionality, a theoretical framework grounded in scholarship and activism by feminists of colour (Collins and Bilge, 2020; May, 2015). Intersectionality contends that: 1) social identities are not singular but multiple and intersecting; and 2) inequity is rarely caused by a single factor or category; instead, oppression and privilege are shaped by multiple axes of social division. A key focus of intersectionality is thus to not simply describe where inequity exists, but to understand the interconnections and interactions among systems of power (e.g., sexism, racism, classism, nationalism, ableism) (Bowleg, 2012; Carastathis, 2016; Collins and Bilge, 2020). Collins (2002) envisions power as a matrix with structural, hegemonic, disciplinary, and interpersonal domains, warning that "individual biographies are situated within all domains of power and reflect their interconnections and contradictions" (p 287). In intersectionality, gender is always intersecting with race and class to produce multiple forms of masculinities and

femininities that are hierarchically positioned. In North America, the most esteemed representations of masculinity and femininity are associated with “White, heterosexual, affluent, slim, able-bodied men and women, while devaluing and marginalizing racialized minorities, working class, lesbian, gay, trans, and those with disabilities” (Creese, 2015, p. 203).

1.6. Data sources and setting

1.6.1. Intervention (bicycle training course)

In brief, bicycle training courses examined in this dissertation aimed to increase comfort level to ride in various urban environments, including on streets shared with cars, through teaching road safety knowledge and bicycle handling skills. Created and delivered by a Metro Vancouver bicycle advocacy organization, HUB Cycling, bicycle training courses were either publicly offered through the organization’s website (“public courses”) or specifically offered to immigrant-serving agencies for their clients (“agency courses”). Public courses were either 2 or 4.5 h in duration, consisted of one session, and delivered by accredited instructors with an instructor-student ratio of 1:6. Participants were expected to have at least some level of bicycle proficiency (courses were advertised “for anyone who can already ride a bike”). Participants registered for courses online and paid a course fee ($10 to $45). By contrast, agency courses were 4.5 h in duration and spread over two sessions. Courses were open to anyone with any level of bicycling skill. Agency staff registered clients on HUB’s behalf, courses were free, and bicycles and helmets were provided to participants during sessions. Other than these differences, all courses contained the same content. Courses contained: 1) a theoretical component involving slides, and a learning environment encouraging classroom questions; 2) the distribution of written resources (such as municipal bicycling maps); and 3) a bicycle riding session involving practice of bicycling technique in traffic-free areas and on streets with quiet to moderate traffic. Course content and an implicit programme theory is further described in chapter 3 using the Behaviour Change Wheel System.

1.6.2. Primary data sources

This dissertation used a mixed methods sequential explanatory research design, where quantitative and qualitative data were collected in two phases. Quantitative data was collected and analyzed in the first phase, followed by qualitative data collection and analysis to understand trends from the quantitative phase. In this dissertation, I used quantitative analysis to examine patterns and the temporal order of behaviour change, and qualitative analysis to understand participants' bicycling experiences. To do so, I relied on two primary data sources derived from questionnaires and interviews.

1.6.2.1 Quantitative Data

The first phase entailed longitudinal data collection for the Increasing Cycling in Canadian Communities questionnaire. This work was part of a SSHRC-funded multi-site project investigating strategies that could be used to increase the number of people bicycling for transport (The Centre for Active Transportation, 2019). In BC, we looked at adult bicycling training programs offered by HUB as an intervention that aimed to increase bicycling. Participants who agreed to participate in our study were asked to complete surveys before and at 1,3, and 12 months after the course. The questionnaire had items assessing behaviour, attitudes, perceptions, and confidence after participating in the course. Its design was shaped in part to enable comparisons with interventions at different study sites in the pan-Canadian project. Questionnaire data was used in chapter 3 of the thesis to assess the impact that courses had on bicycling uptake.

Recruitment methods are described in detail in chapter 3. In brief, our recruitment was limited to five months each year, aligned with HUB's adult bicycle skills courses training. The questionnaire was piloted in 2015 (data not included in dissertation) and the finalized questionnaire tool was implemented in 2016 and 2017. We recruited people who were registered in a HUB bicycle skills course in advance through email, and in person on the day of their course. People were eligible if they were aged 19 or older and had sufficient English (self-assessed) to complete online surveys (English-language only). They were sent a web link to complete baseline surveys before or within 6 hours of completing their course. Participants who cancelled or missed their course were recruited for the comparison group. Data for everyone were collected across four time points: baseline, 1, 3, and 12 months follow up.

During the 2016 and 2017 season, 558 people registered in 46 HUB bicycle training courses but only 373 met eligibility criteria. Of 46 courses, 18 were specifically delivered to clients of immigrant-serving agencies, and 28 were publicly offered through the HUB website. Chapter 3 analyzes the questionnaire data from the 28 public courses. The questionnaire data were also drawn upon in chapters 4 and 5, to describe interview participants. Questionnaire items are in Appendix A. The questionnaire protocol was approved by the Research Ethics Board at Simon Fraser University and is enclosed in Appendix B.

1.6.2.2 Qualitative data

The “Increasing Cycling in Canadian Communities” cohort served as the sampling frame for interviews with a subset of women participants. Interviews were designed to explain bicycling practices before and after the course in more detail. Thirty-two interviews came from this phase.

Participants who completed either public or immigrant-specific bicycle courses in 2016 and 2017 had indicated on their consent forms if they were willing to be contacted for interviews. From this pool I recruited a sample of women (over 19 years of age) with diversity in terms of bicycling uptake, years in Canada, family status, and neighbourhood. Of the 32 women in the sample, 6 had participated in courses delivered through immigrant-serving agencies. I conducted semi-structured interviews in 2018 (12-26 months after women completed courses). Interviews (median length 75 minutes) were conducted in English, at a place according to participants’ wishes (typically at the research unit, but also at participants’ homes, workplaces, park, library, or by phone). Recordings were transcribed verbatim by a transcriptionist, and I double-checked for accuracy before coding for analysis. All participants were given pseudonyms for analysis and reporting. Interview data was used in chapters 4 and 5 of the thesis to generate insights into participants’ everyday mobilities and material conditions, how these were entwined with their bicycling practices, and the impact of the bicycle skills course. Further details about recruitment, data collection, analysis, and methodological rigour are described in chapters 4 and 5. The interview schedule is enclosed in Appendix C. The interview protocol was approved by the Research Ethics Board at Simon Fraser University and is enclosed in Appendix D.

1.6.3. Metro Vancouver setting

Metro Vancouver is comprised of 22 municipalities (including the city of Vancouver) with diverse urban form and transportation infrastructure. The Metro Vancouver region is ethnically diverse: approximately half (49%) of Metro Vancouver residents identify as people of colour, with most (75%) claiming Chinese, South Asian, or Filipino identity. The region is also characterized by high levels of immigration: 41% of all Metro Vancouver residents immigrated to Canada at some point in their lives; and 6% would be characterized as newcomers (immigrated between 2011-2016) (Statistics Canada, 2017a). Proportions are similar for the city of Vancouver (Statistics Canada, 2017b).

Metro Vancouver has promoted itself as a place for healthy living, with an emphasis on fitness, an active outdoor lifestyle, and sport (Haines-Saah et al., 2013). Its mild climate is conducive to year-round bicycling. Across Metro Vancouver bicycle journey-to-work mode share is 2.3%, but 6.1% within the city of Vancouver itself (Statistics Canada, 2017b, 2017a). Vancouver's bicycling rates are high for a North American city, and bicycle journey-to-work mode share has nearly doubled from 3.3% in 1996 to 6.1% in 2016 (Statistics Canada, 2017a, 1996).

Vancouver has been promoting bicycling and has invested in improving and extending its bicycle route network in recent decades. The 1990s were characterized by a decision to prioritize local street bikeways—traffic-calmed streets running near and parallel to arterial roads, equipped with bicyclist-activated road signals—as the optimal infrastructure for the city (Hirschberger, 2012; Mah, 1995). In 1990, the city had 42 km of bikeways, including 34 km of protected bike lanes along the seawall and under the Expo Skytrain line, and by 2006, the city had added 133 km of bike routes. In 2016, the total network was 283 km, comprised mainly by local street bikeways (54%), protected bike lanes (physically separated from motor vehicles, 28%), painted bike lanes (13.5%), and shared use lanes (painted markings on busy streets, 4.5%) (City of Vancouver, 2020, 2019). While Vancouver has been doing much to promote bicycling, it should also be noted that during this period the city has become one of the least affordable places to live in North America (Grigoryeva and Ley, 2019) and this impacts access to different areas of the regional bicycle route network. The bicycle route network is denser within

the city of Vancouver than in the surrounding municipalities, and with highest route density in the neighbourhoods closest to the downtown area.

In 2011 city council approved the Greenest City Action Plan, with the goal to make Vancouver the most sustainable city in the world by 2020 (City of Vancouver, 2012a). Two years later, the City adopted Transportation 2040 Plan which set a target to have two-thirds of all trips in Vancouver made by either walking, bicycling, or public transit by 2040 (City of Vancouver, 2012b). The Plan also expressed the vision “to make cycling safe, convenient, comfortable, and fun for people of all ages and abilities” (City of Vancouver, 2012b, p. 70). It contained objectives to promote urban bicycling to a broader spectrum of the population, particularly women, children, new Canadians, and older adults. To accomplish this, Vancouver is pursuing promotion and education initiatives to complement expansions in physical infrastructure. Through delivering education to children and adults, the City hopes to improve safety, confidence, and reduce road user conflict.

1.7. Dissertation structure

1.7.1. Review of chapters

My manuscript-based thesis presents four stand-alone chapters, bookended with introductory (chapter 1) and concluding (chapter 6) chapters. Chapter 1 reviews the background justification and study context, theoretical frameworks, intervention case study, and methods. Chapter 2 provides a review of existing literature of bicycle training interventions, and introduces the concepts of programme theory and context. This chapter situates the findings of subsequent chapters within an evidence base for bicycle training courses. In Chapter 3 I examine the impact a bicycle course delivered in Metro Vancouver by HUB Cycling, using longitudinal questionnaire data to compare changes in bicycling behaviour and confidence between course participants and a comparison group over one year. This chapter also uses the Behaviour Change Wheel system to describe course content, retrospective programme theory, and to understand the limitations of the intervention. The analysis finds that neither group increased bicycling over 12 months, nor were course participants more confident than the comparison group one year later. Chapters 4 and 5 therefore shift the focus toward examining the relationship between context and how participants responded to the intervention: how

and why the intervention helped or did not help them to engage in bicycling. These chapters use interview data to examine socially and materially embedded practices to explore bicycling patterns and potential avenues of change. Both chapters engage Social Practice Theory supplemented with theory on gender socialization to understand underlying gendered processes in bicycling uptake and maintenance. Chapter 4 examines competences (rules and skills) that women at different phases of bicycling enact to ride in car-dominated cities, and what was learned and could be applied from the bicycle skills course. The experiences of women with children required further analysis, which is presented in chapter 5. Chapter 6 concludes the work and ties the analysis together. It summarizes key findings and describes what they might imply for bicycle intervention planning and policy.

Chapter 2.

Changes in bicycling frequency in children and adults after bicycle skills training: A scoping review

Abstract

Background: Encouraging more trips by bicycle is often an objective of bicycle skills training. Bicycle skills training programs have been implemented in several countries, cities, and schools, but few evaluations measure changes in bicycling. We conducted a scoping review to identify and describe evidence of changes in bicycling frequency associated with bicycle skills training. We also describe and compare the theoretical basis, context, and training content of bicycle skills trainings that might be associated with changes in bicycling.

Methods: We searched six electronic databases, grey literature websites, Google Scholar, and citations in relevant articles for pre- and post-test studies of bicycle skill training interventions which measured bicycling frequency in children or adults. We assessed the theory, context, and content of the bicycle skills training interventions using pre-defined concepts and a behaviour change technique taxonomy.

Results: We found 12 studies. Six studies assessed programs for adult populations, of which five reported increases in overall bicycling and three reported increases in bicycling to work. Six studies assessed programs for children, of which five reported increases in overall bicycling and three reported increases in bicycling to school. Information about the statistical significance of these results was sometimes missing. Studies described intervention content adequately, but poorly reported details about intervention theory and context. No associations were found between intervention content and changes in bicycling frequency.

Conclusions: Bicycle skills training increases participants' bicycling, but evidence is heterogeneous among a small number of studies. Sparse reporting limited our ability to detect associations between changes in bicycling frequency and the training theory, context, or content. Future studies should strive to report details on theory, context, and content to help assess effectiveness and generalizability.

2.1. Introduction

Bicycling offers important health, transport, and environmental benefits (Götschi et al., 2016; Lindsay et al., 2011; Zahabi et al., 2016), and cities around the world are looking for potential ways to increase levels of active travel by bicycle. Together with supportive infrastructure and changing social environments, experts suggest that bicycle skills training has potential for increasing ridership (Pucher et al., 2010). Developing and implementing effective interventions to increase bicycling relies on understanding its correlates and determinants. Many studies have found that safety concerns from riding in traffic pose a barrier in people's decisions about whether or not to use a bicycle (Lawson et al., 2013; Sanders, 2015; Winters et al., 2012, 2011), as do related constructs such as confidence or comfort (Emond and Handy, 2012; Willis et al., 2015; Xing et al., 2010). Bicycle skills training has been proposed as a strategy to increase bicycling by giving participants greater confidence to ride (Goodman et al., 2016; Rissel and Watkins, 2014).

Bicycle skills training interventions are diverse in aim, delivery mode, and objectives. For example, in terms of aims and objectives, bicycle skills training has been described as helping participants to "overcome skill, knowledge, and confidence related barriers to cycling" (Rissel and Watkins, 2014, p. 135), teaching "road awareness and how to cycle on the road" (Mandic et al., 2016, p. 219), aiming to "increase participation in cycling, particularly cycling for transport trips" (Hawley and Mackie, 2015, p. 6), or as encouraging children to "cycle more safely, more often, by giving them the skills and confidence to cycle" (Goodman et al., 2015, p. 513; Johnson et al., 2016, p. 52).Bicycle skills training can serve diverse audiences with respect to skills and experience, ranging from children and adults learning to ride for the first time, to those with some basic or even advanced bicycle handling skills wishing to gain further competence in using bicycles in urban environments. However, there are few published studies of bicycle skills training, and little evidence is available to demonstrate whether such training does encourage more bicycling. Most studies of children's bicycle training have measured changes in knowledge, skills, attitudes, helmet use, safety awareness, or injury rates (Hooshmand et al., 2014; Lachapelle et al., 2013; Richmond et al., 2013). There has not been a synthesis of evidence on the impact of bicycle skills training on increases in

bicycling frequency (i.e., changes to the amount of bicycling), despite this being a primary rationale for training.

Moreover, little is known about which programs may work most effectively, under what conditions, and for which populations. An important aspect of designing and reporting interventions and evaluations is drawing explicit links between theory, context, and content. Researchers have called for further development into intervention reporting, including better descriptions of theoretical approaches used to guide intervention designs and measured outcomes (Bartholomew and Mullen, 2011; Davidoff et al., 2015; Moore and Evans, 2017), consideration of context (Hawe, 2015b; Shoveller et al., 2016), and more detailed intervention description (Albrecht et al., 2013; Borek et al., 2015; Hoffmann et al., 2014; Michie et al., 2009). Researchers are encouraged not only to establish that an intervention works, but also to identify and explain the specific ways in which it works (Moore et al., 2015). Theory becomes especially important for interventions that are delivered in different contexts or that are tailored or modified to meet the needs of participants (Walshe, 2007), such as bicycle skills training.

Research on population-level bicycling rates across countries and cities indicates that certain contextual elements underpin higher bicycle mode share. We understand context as an essential foundation that "interacts, influences, modifies, facilitates or constrains the intervention and its effectiveness" (Coles et al., 2017, p. 2). Higher mode shares are found in countries and cities where there are government policies and programs to promote bicycling and extensive infrastructure and land-use policies to support bicycling (Lanzendorf and Busch-Geertsema, 2014; Pucher et al., 2010; Pucher and Buehler, 2008; Rietveld and Daniel, 2004). Sociocultural aspects are also important, such as "bicycle culture" or attitudes and meanings toward using bicycles (Aldred and Jungnickel, 2014; Goetzke and Rave, 2010; Klinger et al., 2013). Considering these contextual differences, we would expect the effects of bicycle skills training to differ by place and population.

Scoping reviews can identify current evidence and gaps to inform concepts, frameworks, and practice (Arksey and O'Malley, 2005; Levac et al., 2010; Peterson et al., 2017; Pham et al., 2014; The Joanna Briggs Institute, 2015; Tricco et al., 2016). Given the need for data on bicycling uptake and the limited body of knowledge, we conducted a scoping review to explore existing peer-reviewed and grey literature. Our

aim is to identify and describe evidence on changes in bicycling frequency associated with bicycle skills training interventions. Within the identified studies, we also compared the theoretical basis, context, and training content of bicycle skills training interventions that might be associated with increased bicycling frequency. In doing this, we respond to recommendations that reviews should explore intervention content, examine the role of theory (Bird et al., 2013), and go beyond asking 'does it work' to 'does it work in this context?' (Bates and Ellaway, 2016).

2.2. Methods

Our scoping review followed a pre-defined 5-stage process: 1) identifying research question and 2) relevant studies; 3) selecting studies; 4) charting data; 5) reporting results (Arksey and O'Malley, 2005; Levac et al., 2010; The Joanna Briggs Institute, 2015). We describe these stages below. The scoping review protocol may be obtained from the study authors.

2.2.1. Scoping review question

To construct the research question, we used the Population, Concept, and Context framing (The Joanna Briggs Institute, 2015). Our population is participants in a bicycle skills training. Our concept, bicycle skills training, is face-to-face training with a "hands-on" component where participants ride a bicycle. The context of interventions is not limited to specific geographic locations, settings or participant demographics. Our search was limited to period 1980-2017. The outcome of interest to the scoping review is any change in bicycling frequency before and after intervention participation.

2.2.2. Identifying relevant studies

A university librarian assisted with developing the search strategy. We used multiple search strategies: 1) literature indexed in academic databases; 2) grey literature indexed in web sources (defined as grey literature as reports, evaluations, and theses not appearing in scholarly journals); and 3) hand searching. We restricted our search to publication dates 1980-2017 and English language. In June 2017, we searched six academic databases (CINAHL, Ovid MEDLINE, PsycINFO, SPORTDiscus, Transport Research International Documentation (TRID), and Web of Science) using the following

terms: ((“bicycl*” OR “bike” OR “biking” OR “cycl*”) AND (“intervention” OR “training” OR “course” OR “workshop” OR “education” OR “skill*”) AND (“transport*” OR “commut*” OR “street” OR “urban”)) to focus on utilitarian bicycling. Additionally, three grey literature databases (Canadian Electronic Library, Grey Literature (greylit.org), ProQuest Dissertations and Theses) were searched, as well as Google Scholar. The search strategy was documented by title of the database searched, date of the search, the complete search string that was used, and the number of articles found. Hand searching strategies included checking references from relevant articles.

2.2.3. Study selection with predefined inclusion/exclusion criteria

Our inclusion criteria specified three criteria: 1) pre- post-test study design; 2) at least one measure of bicycling frequency; 3) and an intervention with a hands-on training component. Studies were excluded if the interventions targeted injury treatment, weight loss, sport racing, oxygen intake capacity or other fitness performances. Evaluation reports not publicly available were also excluded. Titles and abstracts of publications obtained by the search strategy were independently screened by two reviewers (SS and DD). A third reviewer (MW) adjudicated disagreements.

2.2.4. Charting data

The data were extracted and charted independently by two reviewers (SS, DD) in Microsoft Excel. Disagreements were resolved by discussion and consultation with a third author (MW). Six types of information were collected: 1) study characteristics; 2) participant description; 3) assessment of the extent to which interventions were based on theory; 4) description of broader intervention context; and 5) intervention description, including 6) behaviour change techniques.

Intervention descriptions were analyzed to identify behaviour change techniques (Michie et al., 2013) included in the training. We completed online training to learn appropriate coding. When intervention descriptions in articles contained insufficient detail to code for behaviour change techniques, we obtained intervention training manuals or contacted authors of studies.

2.2.4.1 Reporting intervention theory, context, and content

Theory

In this paper, we use the term *theory* to mean a systematic way of understanding events or situations, informed by a set of concepts that explain or predict these events/situations by specifying relationships between variables (Glanz and Bishop, 2010). In short, theory clearly explains how and why specific relationships between variables lead to specific outcomes (Nilsen, 2015). These do not need to be formal "off-the-shelf" theories (Moore and Evans, 2017, p. 133); we use the term theory to also mean other approaches where cause-and-effect associations are explicit and clearly mapped to the intervention design (Breuer et al., 2016; Jones and Ogilvie, 2012; Kok et al., 2016; Michie et al., 2016). Thus, the term theory here means both theories of behaviour change as well as the conceptual frameworks that guide the design and evaluation of interventions. We used one item from Michie and Prestwich's (2010) theory coding scheme, a standardized tool with good reliability, to identify and describe the theoretical basis for bicycle skills training. This was "is theory mentioned", with three considerations: 1) if an explicit *theory is mentioned* anywhere in the manuscript, even if the intervention is not based on it; 2) if the study mentions the *predictors of the behaviour* in the introduction or methods sections; and 3) if the *intervention is based* on a theory or theories.

Context

To conceptualize and describe broader intervention context, we used a framework by Pfadenhauer and colleagues (2017) developed to provide guidance for reporting context in reviews and primary studies. In this framework, context comprises seven domains at scales beyond that of the individual: geographical, epidemiological, sociocultural, socioeconomic, ethical, legal, and political. We chose domains based on what the literature has suggested to be important determinants of bicycling: policies (political or legal domain), infrastructure (geographical), and the social milieu (sociocultural). We assessed if articles had reported contextual information across three areas: 1) political or policies to promote bicycling; 2) built environment characteristics (such as bicycling infrastructure) of geographical location; and 3) bicycling prevalence in the general or target population as a broad proxy for social norms toward bicycling.

Content

We report intervention description (setting, provider, format, duration) and use a taxonomy of 93 behaviour change techniques (Michie et al., 2013) to further describe the components of the bicycle skills training interventions. Behaviour change techniques have been used in reviews to link intervention content to theory, and to facilitate intervention comparison and evaluate technique efficacy (Michie et al., 2016).

Collating, summarizing, and reporting results

We present data summaries in tables accompanied by narrative interpretations. Interventions delivered to adults and children (up to 16 years) are considered separately. As this review did not include human subjects, no institutional review board approval was required.

2.3. Results

Overall, 1978 articles were identified through database, citation, and hand searching. In total 292 duplicates were removed (Figure 2.1). Twelve studies met inclusion criteria: six in adult populations and six in children. Six of these studies are peer-reviewed articles (Ducheyne et al., 2014; Johnson and Margolis, 2013; Rissel and Watkins, 2014; Telfer et al., 2006; van Lierop et al., 2016; Zander et al., 2013), three are reports from the grey literature (two from Transport for London on the same intervention but data could not be pooled; Hatfield et al., 2017), and three are theses (Groesz, 2007; Jones, 2017; Montenegro, 2015).

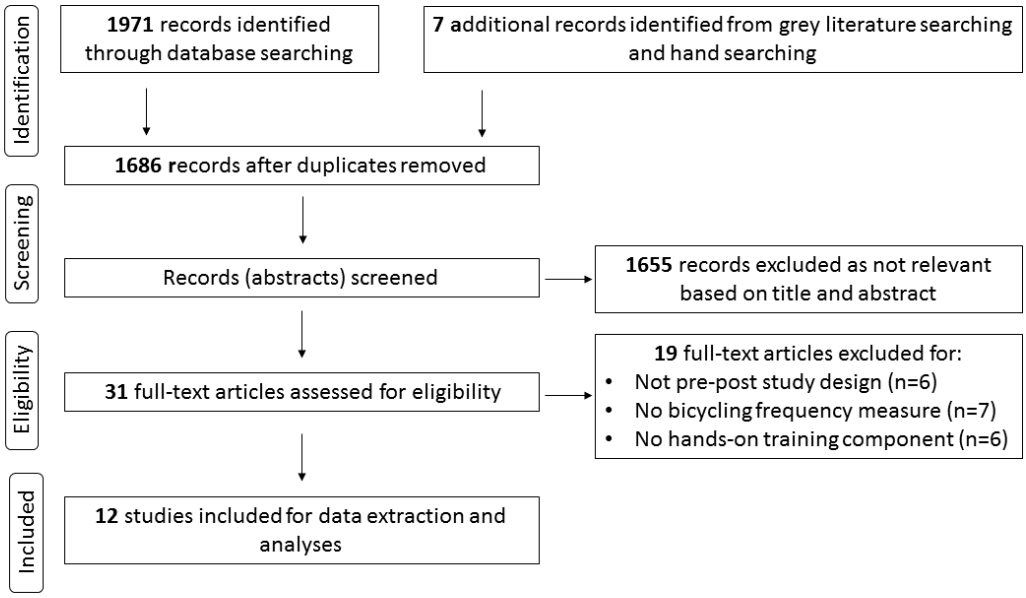

Figure 2.1 Selection of studies into the review

2.3.1. Characteristics of studies

Table 2.1 provides a detailed description of the characteristics of included studies. All six studies in adult populations were from Australia or the UK, while the six studies focusing on children were more geographically diverse (Belgium, Ireland, Australia, Canada, and the USA). One included a randomized control group (Ducheyne et al., 2014), and three included a comparison (non-randomly assigned control) group (Groesz, 2007; Hatfield et al., 2015; Jones, 2017). Response rates were not always reported, but all studies reported follow up rates. Five had follow up rates of 90% or higher (Groesz, 2007; Hatfield et al., 2015; Jones, 2017; Montenegro, 2015; Telfer et al., 2006), and four studies 60% or less (Johnson and Margolis, 2013; Rissel and Watkins, 2014; Transport for London, 2017, 2016).

Table 2.1 Characteristics of bicycle skills training studies included in the review (n=12)

Author, Year, Country	Follow-Up(s) After Training	Study design, group (n)	Bicycling Frequency Measurement Tool	Bicycling Frequency Measurement(s)	Bicycling Frequency Findings Changes relative to baseline	Direction of change[a]	Secondary Findings
Adult Studies							
Johnson & Margolis, 2013, UK	3 months	One-group pretest-posttest design pre (471)/ post (130)	Self-reported online survey	1) # days/previous week bicycling >30 min; 2) # days/previous week bicycled to work	1) mean increase +0.81 days/wk bicycling >30 min* 2) mean increase +0.67 days/wk bicycling to work*	1) +* 2) +*	Increase in confidence
Rissel & Watkins, 2014, AU	0, 3, 12 months[b]	One-group pretest-posttest design using repeated posttest measures pre (4145)/ post 0m[b,c] (2250), post 3m[c,d] (423), post 12m[c,d] (125)	Self-reported paper survey & telephone interview	1) bicycle in previous week (y/n) 2) bicycle in previous month (y/n)	1) 16% increase in weekly bicycling at 3m[e]; 12% increase at 12m[e] 2) 30% increase in monthly bicycling at 3m[e]; 14% increase at 12m[e]	1) +[e] 2) +[e]	Increase in confidence; decrease in weight at 12m*
Telfer et al., 2006, AU	2 months	One-group pretest-posttest design pre (113)/ post (105)	Self-reported survey & telephone interview	1) # days/previous week bicycling; 2) mins/previous week bicycling; 3) # days/previous week bicycling to work	1) no change in days/wk bicycling 2) mean increase of 10.4 minutes/wk bicycling 3) no change in days/wk bicycling to work	1) 0 2) + 3) 0	Increases in skills, confidence, other Moderate to Vigorous Physical Activity (MVPA)*
Transport for London (TfL) report, 2016, UK	3, 12 months	One-group pretest-posttest design using repeated posttest measures	Self-reported online survey	# days bicycling[f] for 1) commuting, 2) errands, 3) leisure	Increases in bicycling at 3m[e] follow up for 1) commuting (+0.77 days/wk);	1) +[e] 2) +[e] 3) +[e]	Increases in access to bikes, safety, confidence[e]

Author, Year, Country	Follow-Up(s) After Training	Study design, group (n)	Bicycling Frequency Measurement Tool	Bicycling Frequency Measurement(s)	Bicycling Frequency Findings Changes relative to baseline	Direction of change[a]	Secondary Findings
		pre (800)/ post 3m[c] (258), post 12m[c] (101)			2) errands (+0.89 days/wk); 3) leisure (+0.82 days/wk)		
TfL report, 2017, UK	3, 12 months	One-group pretest-posttest design using repeated posttest measures pre (724)/ post 3m[c] (220), post 12m[c] (32)	Self-reported online survey	# days bicycling[f] for 1) commuting, 2) errands, 3) leisure	Increases in bicycling at 3m[e] follow up for 1) commuting (+0.73 days/wk); 2) errands (+0.47 days/wk); 3) leisure (+0.66 days/wk)	1) +[e] 2) +[e] 3) +[e]	Increases in access to bikes, safety, confidence[e]
Zander et al., 2013, AU	0 months[b]	One-group pretest-posttest design pre (17)/ post (11)	Semi-structured interviews	1) Meet 2 hr/wk bicycling target (y/n)	1) 9 of the 11 participants (82%) met the 2 hr/week bicycling target[e]	1) +[e]	Increases in mental health, physical fitness, confidence[e]
Child Studies							
Ducheyne et al., 2014, BE	0, 5 months[b]	Randomized Control Trial Three groups: 1) intervention pre (44)/ post (25); 2) intervention+ pre (47)/ post (34); 3) waitlist[g] pre (44)/ post (35)	Self-reported paper survey (parents)	1) # minutes child biked to school in the previous week	Intervention group Mean increase of 7.1 mins/wk at 0m; mean decrease of 4.1 mins/wk at 5m Intervention+ group Mean decrease of 4.4 mins/wk at 0m; mean decrease of 4.8 mins/wk at 5m Waitlist group	1) 0/0	Increases in skills*; no change in parent attitudes

Author, Year, Country	Follow-Up(s) After Training	Study design, group (n)	Bicycling Frequency Measurement Tool	Bicycling Frequency Measurement(s)	Bicycling Frequency Findings Changes relative to baseline	Direction of change[a]	Secondary Findings
					Mean decrease of 5.3 mins/wk at 0m; mean increase of 3.5 mins/wk at 5m		
Groesz, 2007, US	5 months[b]	Quasi-experimental Two groups: 1) intervention pre (74)/ post (67); 2) waitlist[h] pre (44)/ post (43)	Self-reported paper survey; daily tally (children)[j]	1) # days biked to school over 10 days[i]; 2) # days biked to school in previous 5 days; 3) hrs/wk recreational bicycling[f]	Intervention group 1) mean increase of 0.06 days/10 days bicycling to school 2) mean decrease of 0.07 days/5 days bicycling to school 3) mean increase of 0.12 hrs/wk recreational bicycling* Waitlist group 1) mean decrease of 0.16 days/10 days bicycling to school 2) mean increase of 0.09 days/5 days bicycling to school; 3) mean decrease of 0.42 hrs/wk recreational bicycling	1) + 2) - 3) +*	Increases in knowledge, motivation, self-efficacy*
Hatfield, 2015, AU	0, 3 months[b]	Quasi-experimental Two groups: 1) intervention pre (112)/ post 0m[b,c] (110), post 3m[c] (108);	Self-reported online survey (children)	1) bicycle in previous 2 weeks (y/n); 2) bicycle to school previous 2 weeks (y/n);	Intervention group 1) 5% increase in bicycling at 0m*; 2% increase at 3m	1) +*/+ 2) +/+* 3) +/+* 4) +/+* 5) +/-	Increases in confidence, knowledge*

Author, Year, Country	Follow-Up(s) After Training	Study design, group (n)	Bicycling Frequency Measurement Tool	Bicycling Frequency Measurement(s)	Bicycling Frequency Findings Changes relative to baseline	Direction of change[a]	Secondary Findings
		2) waitlist[h] pre (30)/ post 0m[b,c] (35), post 3m[c] (28)		3) bicycle using bike lanes previous 2 weeks (y/n); 4) bicycle on road without bike lanes previous 2 weeks (y/n); 5) # days bicycling/ previous 2 weeks on paths or roads	2) 5% increase in bicycling to school at 0m; 6% increase at 3m* 3) 3% increase in bicycling using bike lanes at 0m; 7% increase at 3m* 4) 4% increase in bicycling on road at 0m; 8% increase at 3m* 5) mean increase of 0.38 days/2 weeks bicycling on path or road at 0m; mean decrease of 0.14 days/2 weeks at 3m Waitlist group Issues with waitlist group data and not reported		
Jones, 2017, IE	0, 1, 6, 12 months[b,c]	Quasi-experimental Two groups: 1) intervention pre (328)/post 0m[b,c,k], post 1m[c,k], post 6m[c,k], post 12m[c,k];	Self-reported survey paper (children)	1) ever bicycled to school (y/n); 2) bicycled to school in previous week (y/n)	Intervention 1) 9% increase in ever bicycling to school at 0m; 19% increase at 1m*; 21% increase at 6m*	1) +/+*/+* 2) +*/+*/+*	Increases in skills, confidence, attitudes*

Author, Year, Country	Follow-Up(s) After Training	Study design, group (n)	Bicycling Frequency Measurement Tool	Bicycling Frequency Measurement(s)	Bicycling Frequency Findings Changes relative to baseline	Direction of change[a]	Secondary Findings
		2) waitlist[h] pre (303)/ post 0m[b,c,k], post 1m[c,k], post 6m[c,k], post 12m[c,k]			2) 20.5% increase in weekly bicycling to school at 0m*; 8.5% increase at 1m*; 13.5% increase at 6m* Waitlist group 1) 4% increase in ever bicycling to school at 0m; 7% increase at 1m; 10% increase at 6m 2) 0.9% increase in weekly bicycling to school at 0m; 3.9% increase at 1m; 4.1% increase at 6m		
Montenegro, 2015, US	0 months[b]	One-group pretest-posttest design pre (1575)/ post (1451)	Self-reported paper survey (children)	1) bicycle to school sometimes (y/n); 2) ride bike once/week or more (y/n)	1) 5% increase in bicycling to school[e,f]; 2) 7% increase in weekly riding[e,f]	1) +[e] 2) +[e]	Increases in skills, confidence[e]
van Lierop et al., 2016, CA	3 months	One-group pretest-posttest design pre (80)/ post (51)	Self-reported online survey (children and parents)	1) bicycle to school ("a lot like me")[i]; 2) bicycle on weekend ("a lot like me")[i]; 3) to school when weather allows (parents only, y/n);	1) 6% increase reported by children; 16% increase reported by parents 2) 18% increase reported by children*; 20% increase reported by parents	1) +/+ 2) +*/+ 3) +* 4) -[e]	Increases in positive attitudes, safety, skills*

Author, Year, Country	Follow-Up(s) After Training	Study design, group (n)	Bicycling Frequency Measurement Tool	Bicycling Frequency Measurement(s)	Bicycling Frequency Findings Changes relative to baseline	Direction of change[a]	Secondary Findings
				4) # days/wk ride bicycles in spring/summer [f] (children only)	3) 24% increase bicycling to school reported by parents* 4) decrease in proportion of children choosing "3-5 days/week"[e]		

***** Results are statistically significant

[a] + = increase; - = decrease; 0 = no change or null results; follow up measures separated by /

[b] 0 months = follow-up immediately after program delivery

[c] Length of follow-up after program delivery

[d] Follow-up at 3 and 12 months was a 10% random sample of original survey

[e] No statistical testing was reported

[f] No recall period specified in questionnaire item

[g] Randomly assigned control group waitlisted to eventually receive the intervention

[h] Non-randomly assigned comparison group waitlisted to eventually receive the intervention

[i] Respondents asked to respond to question with a 3-point Likert scale; only changes in proportion of children/parents choosing top of Likert scale ("a lot like me") reported

[j] Children reported travel mode to school via daily tally sheet

[k] Follow up retention not reported separately for intervention/comparison group, but only for overall study participants: at post 0m (575); post 1m (571); post 6m (571); post 12 m (567)

[k] + = increase; - = decrease; 0 = no change or null results; follow up measures separated by /

All studies had multiple time points, but follow-up time periods varied. Three studies assessed outcome measures only at baseline and at the end of the intervention period (Montenegro, 2015; van Lierop et al., 2016; Zander et al., 2013), while the other nine studies assessed outcomes between 2-12 months post-intervention. Five of the nine studies included multiple post measurements (Hatfield et al., 2015; Jones, 2017; Rissel and Watkins, 2014; Transport for London, 2017, 2016). Of these, three found that bicycling increases were the greatest shortly after the intervention (Rissel and Watkins, 2014; Hatfield et al., 2015; Jones, 2017).

There were a variety of measures used to assess bicycling, all based on self-reported questionnaires or interview data. Most studies asked about bicycling within a specified recall period, for example, number of time bicycled in the previous week, while others asked about bicycling more generally. In terms of bicycling purpose, some papers only measured overall bicycling (n=2) (Rissel and Watkins, 2014; Zander et al., 2013), others only measured bicycling specific to commuting (n=2) (Ducheyne et al., 2014; Jones, 2017), and some included both as separate outcomes (n=8) (Groesz, 2007; Hatfield et al., 2015; Johnson and Margolis, 2013; Montenegro, 2015; Telfer et al., 2006; Transport for London, 2017, 2016; van Lierop et al., 2016).

Table 2.2 outlines characteristics of study participants. Studies always described participants by gender and often by age, but rarely other defining characteristics of the group such as ethnicity and socioeconomic status. Among adult programs, participants were predominantly women, although no program was specifically women-oriented. Courses aimed at children were delivered in schools, with reported populations between 8 and 14 years of age.

Table 2.2 Baseline characteristics of participants in bicycle skills training studies

Author, Year	Study population size # people receiving intervention (n)[a]	Baseline Sample (n)	Ethnicity (% self-identifying as Black, Asian, Latino/a, or Indigenous)	Gender (% female)	Age[b]	Other	Reported bicycle experience
Adult Studies							
Johnson & Margolis, 2013	471	471	Not reported	82	adults	46% own bicycle	Not reported
Rissel & Watkins, 2014	6700	4145	Not reported	70	17% 18-30, 28% 30-44, 33% 45-59, 23% 60+	38% do not have bicycle; 61% registered in Austcycle level 1 (i.e., beginner) 49% Body Mass Index (BMI) > 25	9% never bicycled; 24% did not bicycle for one year or more; 12% did not bicycle in past year[c]
Telfer et al., 2006	113	105	Not reported	75	87% 25-54	36% live < 5km from work; 77% rated fitness 'fair' or 'good'	Not reported
TfL report, 2016	8650	800	43	76	37% 16-34, 45% 35-54, 17% > 55	65% have access to a bicycle; 86% registered in Bikeability level 0/1 (i.e., beginner)	Not reported
TfL report, 2017	13289	724	42	76	43% 16-34, 46% 35-54, 11% > 55	68% have access to a bicycle	Not reported
Zander et al., 2013	17	17	Not reported	71	49-72 (mean 61)	Sample is higher socio-economic status (SES) than national average	Not reported

Author, Year	Study population size # people receiving intervention (n)[a]	Baseline Sample (n)	Ethnicity (% self-identifying as Black, Asian, Latino/a, or Indigenous)	Gender (% female)	Age[b]	Other	Reported bicycle experience
Child Studies							
Ducheyne et al., 2014	135[a]	130	Not reported	48	8-10 (mean 9.3, SD 0.5)	86% normal weight; 74% live <3 km from school; 76% higher SES	Not reported
Groesz, 2007	830[a]	118	39	59	9-12 (mean 10.4, SD 0.6)	Mean BMI 20.36 (SD=4.57)	11% (n= 9 intervention; n=4 waitlist) never bicycle
Hatfield, 2015	356[a]	136	Not reported	60	10-14 (mean 11.8, SD 1)	Not reported	6% (n=7) of intervention group did not bicycle
Jones, 2017	Not reported	631	Not reported	52	74% 8-10, 26% 13-14	81% own bicycle	Not reported
Montenegro, 2015	Not reported	1575	70	45	8-12 (mean 10.2)	Not reported	15% (n=240) did not know how to bicycle
van Lierop et al., 2016	153	80	Not reported	44	10-11 (mean 11)	93% have access to a bicycle	4% never bicycle

[a] In studies with randomized control and quasi-experimental designs, study population size includes both children receiving intervention and children included in control/comparison group

[b] Age ranges, means, and standard deviations listed if reported

[c] Questionnaire item asked "When was the last time you rode a bike?"

2.3.2. Changes in bicycling frequency

There was variability in findings on changes in bicycle frequency after the bicycle skills training. Most studies reported some increase in bicycling, although the effect size of the intervention was not always reported (Table 2.1). Five of the six adult intervention studies reported an increase in overall bicycling following the bicycle skills training (all but Telfer et al., 2006), and three found increases in bicycling to work (Johnson and Margolis, 2013; Transport for London, 2017, 2016). Two of the six studies in children found increases in overall bicycling (Hatfield et al., 2015; Montenegro, 2015), three studies (Hatfield et al., 2015; Jones, 2017; Montenegro, 2015) found increases in bicycling to school, and one found increases in recreational bicycling (Groesz, 2007). No significant change in bicycling was found in one of the adult studies (Telfer et al., 2006) or in one of the children studies (Ducheyne et al., 2014). In one study, the net change in bicycling frequency was unclear as the parent and children-reported outcomes differed (van Lierop et al., 2016). Across studies data was not always reported out in a manner to enable calculation of standardized effect sizes (e.g., Cohen's d). For example, some studies reported percentage increases (e.g., Rissel and Watkins, 2014; Montenegro, 2015).

All studies assessed other outcomes in addition to the bicycling frequency, mostly about skills, knowledge, and confidence. Skills and knowledge were measured by questionnaire in several studies on children, with the exception of three studies that used direct observation by researchers (Ducheyne et al., 2014; Hatfield et al., 2015; Jones, 2017). Measures of confidence were typically taken from questionnaire responses. Eleven of the twelve studies measured confidence, and all found that confidence increased after the intervention. However, results for confidence do not necessarily align with results for bicycling frequency. One of the studies of adults found no bicycling increase, despite a confidence increase (Telfer et al., 2006). Similarly, one of the studies of children found that increases in children's confidence did not translate to increased bicycling to school (Groesz, 2007).

Additionally, several studies conducted subgroup analysis, analyzing bicycling increases by experience, training level, gender, or age. Four studies specifically assessed new bicycling from a baseline of zero. Of these, three examined changes in bicycling among those who said they had not bicycled at all or in recent years: one in

adults found high rates of uptake 71% and 77% (at three and twelve month follow up) for those who had not bicycled at all or in recent years (Rissel and Watkins, 2014). In two of the studies on children, 9 of 74 had never bicycled and 56% started bicycling (Groesz, 2007), and 7 of 108 had never bicycled and 86% started bicycling (Hatfield et al., 2015). A fourth study considered only bicycling in the past week, and found that among the 55 of 113 participants who had not bicycled at baseline, there was a 40% increase at follow-up (Telfer et al., 2006).

A study that looked at training level found that bicycling increases were associated with higher levels of training (i.e., people were more likely to bicycle if they completed Levels 2 or 3 of Bikeability) (Johnson and Margolis, 2013). Transport for London (2016, 2017) examined bicycling frequency by gender and found that men were more likely to bicycle pre-intervention, but the bicycling gender gap narrowed post-intervention. One study (Jones, 2017) examined bicycling frequency by gender and age among children and found that both boys' and girls' bicycling to school increased post-intervention over a one year period, but the shape of their trajectories differed. Girls' increases peaked immediately post-intervention, whereas boys' increases were sustained over time. This study also compared three age groups: 8-9, 9-10, and 13-14 years, and found that increases in bicycling frequency among younger children were far greater than that of their teenage counterparts.

2.3.3. Descriptions of theory

Table 2.3 shows that no studies met all three indicators to fully explain the role of theory in developing the design or evaluation of the intervention, and only one study (Groesz, 2007) met two indicators. This study evaluated BikeTexas Safe Routes to School using Social Cognitive Theory, Theory of Planned Behaviour, and the Social Ecological Model. It hypothesized that the intervention facilitated behaviour change through knowledge (lessons component), motivation/intent (encouragement component), and self-efficacy (hands-on component), as well as aspects outside of each individual child. These extra-individual aspects included factors within the home (such as parental support), the school (such as teacher engagement with the program), and the neighbourhood (operationalized via perceptions of the neighbourhood environment).

Eight other studies mentioned predictors of bicycling behaviour in the introduction or methods sections. These are suggestive that some conceptual framework may have guided the intervention design. For example, (Telfer et al., 2006, p. 155) explained, "the [training] was designed to develop personal skills to facilitate behaviour change; it did not address societal, cultural, or environmental barriers", indicating that the intervention had been developed with specific targets. Given the limited description of theory, we are unable to describe any trends between reporting use of theory and increased bicycling frequency.

Table 2.3 Use of theory by bicycle skills training studies, assessed with Theory Coding Scheme (TCS)

Author, Year	TCS 1: Is an explicit theory mentioned?	TCS 2: Are predictors of target behaviour mentioned?	TCS 3: Is the intervention based on theory?	Overall: Is theory mentioned? (Total Y)
Adult Studies				
Johnson & Margolis, 2013	N	N	N	No (0/3)
Rissel & Watkins, 2014	N	Y	N	Partial (1/3)
Telfer et al., 2006	N	Y	N	Partial (1/3)
TfL report, 2016	N	N	N	No (0/3)
TfL report, 2017	N	N	N	No (0/3)
Zander et al., 2013	N	Y	N	Partial (1/3)
Child Studies				
Ducheyne et al., 2014	N	Y	N	Partial (1/3)
Groesz, 2007	Y	Y	N	Partial (2/3)
Hatfield, 2015	N	Y	N	Partial (1/3)
Jones, 2017	N	Y	N	Partial (1/3)
Montenegro, 2015	N	Y	N	Partial (1/3)
van Lierop et al., 2016	N	Y	N	Partial (1/3)

2.3.4. Descriptions of intervention context

The contextual effect of residing in a place with public policies and supportive infrastructure to encourage bicycling (Buehler and Pucher, 2012; Harms et al., 2016), where bicycling is viewed positively, and where there are higher rates of bicycling can influence people's perceptions and decisions to bicycle (Goetzke and Rave, 2010; Handy et al., 2014; Pucher et al., 2010). We found only 3 of the 12 articles provided this information on all three domains of context (Johnson and Margolis, 2013; Jones, 2017; Rissel and Watkins, 2014), while two provided partial descriptions (Groesz, 2007;

Zander et al., 2013). One provided details in a subsequent article (Hatfield et al., 2017). Four of the bicycle skills training interventions were part of a broader bicycling promotion initiative accompanied by infrastructural investments (Johnson and Margolis, 2013; Jones, 2017; Transport for London, 2017, 2016). These four studies also reported increases in bicycling. One study reporting bicycling increases described an extensive network of already-existing bicycle routes (Hatfield et al., 2017), but other studies reporting increases did not describe infrastructure in the area (e.g. Rissel and Watkins, 2014). Given the limited description of context, we are unable to describe any trends or relationships between bicycling infrastructure, population-level bicycling prevalence, and bicycling increase.

Table 2.4 Context description of bicycle skills training studies

Author, Year	Policy Setting	Extent of Infrastructure	Population Bicycling
Adult Studies			
Johnson & Margolis, 2013	London aims for 5% bicycle trips by 2026; funding through transport and health initiatives; congestion charge reduced driving	New bike share; 12 new bicycle highways; existing network	2% of trips
Rissel & Watkins, 2014	National funding for AustCycle training; little funding allocated for new bicycling infrastructure	Existing network, but little funding allocated for improvements	5% of Australians bicycle for transport
Telfer et al., 2006	Not reported	Not reported	Under 2% commute trips
TfL report, 2016	Mayor's aim is to double the number of people cycling in London by 2023	Not reported[a]	Not reported
TfL report, 2017	Mayor's aim is to double the number of people cycling in London by 2023	Not reported[a]	Not reported
Zander et al., 2013	City funded this and other bicycle skills courses for older adults	Not reported	18% of Australians over 50 bicycled in past year
Child Studies			
Ducheyne et al., 2014	Not reported	Not reported	Not reported
Groesz, 2007	Federal funding provided for the Safe Routes to School programs in Texas	Large urban park network of paths (15 km)	Not reported
Hatfield, 2015	School training aligns with national curriculum[b]	Canberra has one of the most extensive networks in Australia, with off-road paths, on-road bicycle lanes, etc. [b]	Not reported

Author, Year	Policy Setting	Extent of Infrastructure	Population Bicycling
Jones, 2017	Dungarvan awarded funding (€7.2m) in 2012 for infrastructure and behaviour change programs, including school training	Well-connected bicycle network to schools, residences in Dungarvan; new infrastructure around schools during study; no infrastructure in Tramore	Under 2% children bicycle to school in Ireland; 4.5% of students of study area bicycled to school in 2013
Montenegro, 2015	CYCLE Kids program is mandatory in Massachusetts schools	Not reported	Not reported
van Lierop et al., 2016	Not reported	Not reported	Not reported

[a] London bicycling infrastructure described in Johnson & Margolis (2013)
[b] Context reported in subsequent article (Hatfield et al., 2017)

2.3.5. Descriptions of intervention content

There was variation in intervention content and delivery (presence of road ride or not; provider qualification (accredited instructor, school teacher, etc); format (student teacher ratio); and duration) (Table 2.5) and no definitive patterns with increases in bicycling frequency emerged. Although all interventions included a hands-on component (an inclusion criteria of this review), not all included real-world context such as a road ride. Some studies have suggested that entirely traffic-free settings such as playground-only settings may not provide the same training experience as on-road settings (Macarthur et al., 1998). For this reason, some bicycle skill trainings incorporate a supervised road ride as part of the curriculum. Three of the six interventions with children involved a road ride, but only two were associated with increases in bicycling to school (Hatfield et al., 2015; Jones, 2017). Only one of the three interventions in a playground-only setting was associated with increases in bicycling to school (Montenegro, 2015). We were not able to assess how many adult participants had a road ride as part of their bicycle skills training in five studies where training was delivered in discrete progressive levels as neither these numbers, nor bicycling increases, were reported.

In terms of intervention format, adult trainings were delivered either in groups or one to one by accredited instructors; however, no articles provided subgroup analysis by delivery format. Five studies reported that participants without bicycles were provided

with one by the program (Hatfield et al., 2015; Jones, 2017; Montenegro, 2015; Rissel and Watkins, 2014; van Lierop et al., 2016), while other studies made no explicit mention if participants used their own bicycles. While each adult session included on-bike practice, it was sometimes unclear how many of the school-based sessions included on-bike practice. All interventions with children were delivered in physical education class by teachers or university students trained to deliver the curriculum. The duration of bicycle skills training varied: for example, school-based interventions ranged between 3-13 hours total, although we note no relationship between duration and observed change in bicycling. The duration of adult trainings was not described in three studies. Children's programs consisted of more sessions (e.g., 4-15 sessions) than those of adults. Finally, we also collated program aims. All but four bicycle skills training programs explicitly aimed to increase bicycling as a primary aim (Ducheyne et al., 2014; Hatfield et al., 2015; van Lierop et al., 2016; Zander et al., 2013). Of these four, one was not associated with increased bicycling (Ducheyne et al., 2014), and the results of another were unclear (van Lierop et al., 2016).

Table 2.5 Intervention delivery descriptions outlined in bicycle skills training studies

Author, Year	Intervention name	Intervention aims	Setting	Road ride component (y/n)[a]	Provider[b]	Format[c]	Duration[d]	Other
Adult Studies								
Johnson & Margolis, 2013	Bikeability	Increase skills, confidence for road travel; 'more people cycling, more safely, more often'	City-wide	Level 1: N Levels 2 -3: Y	Accredited instructor	1:1 training; 3 levels of programs[e]	Up to 4h	Free courses; program targets new or returning bicyclists
Rissel & Watkins, 2014	AustCycle	Increase number of cyclists, regular physical activity, skills, confidence, opportunities	Communities	Level 1: N Levels 2 -3: Y Level 4: unknown	Accredited teachers	Student-teacher ratio not described; 4 levels of programs[f]	Not described	Free courses; program targets disadvantaged
Telfer et al., 2006	-	Increase frequency, duration of bicycling, skills, confidence for leisure or commute	Community	Y	Bicycle coach	8:1 student to coach ratio[g]	6h (2 x 3h classes)	Free courses; program targets beginner and intermediate
TfL report, 2016	Bikeability	See Johnson & Margolis above	City-wide	Level 1: N Levels 2 -3: Y	Accredited instructor	Group or 1:1 training; 3 levels of program[e,h]	Not described[h]	Free & fee courses[h]
TfL report, 2017	Bikeability	See Johnson & Margolis above	City-wide	Level 1: N Levels 2 -3: Y	Accredited instructor	Group or 1:1 training; 3 levels of program[e,h]	Not described[h]	Free & fee courses[h]
Zander et al., 2013	-	Develop cycling ability, safety, knowledge, confidence	Community	Y	Accredited trainers	Group lessons & 1:1 mentors	4.5h	Program targets older adults

Author, Year	Intervention name	Intervention aims	Setting	Road ride component (y/n)[a]	Provider[b]	Format[c]	Duration [d]	Other
Child Studies								
Ducheyne et al., 2014	-	Teach children to bicycle safely	Schools	N	Masters students trained for study	8:1 student to instructor ratio in class	3h (4 x 0.75h hands-on classes) over 4 weeks	Program included a practical skills test
Groesz, 2007	Safe Routes to School	Enable elementary and middle school students to walk and bicycle to school; improve safety	Schools	N	School teachers	Group in PE class	15 classes	No additional information
Hatfield, 2015	Safe Cycle	Promote defensive riding skills; increase awareness to hazards; develop skills for risk management	Schools	Y	Not described	Group in PE class	8 classes (4 hands-on classes) over 8 weeks	No additional information
Jones, 2017	-	Increase bicycling to school	Schools	Y	Trained sports, exercise, & coaching students	Group in PE class	5h (5 x 1h hands-on classes) over 5 weeks	Program included practical skills test
Montenegro, 2015	CYCLE Kids	Provide physical activity skill, nutrition education	Schools	N	School teachers and police officers	Group in PE class	8 classes over 4 weeks	Program addresses nutrition and physical activity for health
van Lierop et al., 2016	Certificat Cycliste Averti	Teach children how to become safer bicyclists	Schools	Y	School teachers and qualified Velo Quebec guide	Group in PE class	13h (6h hands-on, 6h theory, 1h road ride)	Program included individual on-road exam

a Road ride defined as riding on the street compared to riding in traffic-free environment such as park, parking lot, or playground
b Provider defined as the person who delivered the actual training to participants
c All interventions had an on-bike practice component and off-bike skills/knowledge component
d Duration defined as intervention length and/or number of sessions
e Bikeability offers tiered training courses to address progressive ability level. Bikeability Level 1 teaches beginners to control bicycles in off-road environments; Level 2 teaches to bicycle on the road with light traffic for short journeys; Level 3 teaches negotiating a variety of road and traffic conditions. The training manual (Bikeability Delivery Guide) describes Level 3 as 1:1 format or small groups of 2-3 people bicycling on streets in participants' neighbourhoods
f Austcycle offers tiered training courses to address progressive ability level. AustCycle Level 1 teaches beginners bike safety principles and bike handling skills; Level 2 teaches intermediate riders traffic awareness and safety skills in both traffic-free and low traffic conditions; Level 3 teaches advanced bike handling and traffic skills, starting on quiet roads and progressing to busier roads; Level 4 involves specialized coaching sessions and techniques for outdoor recreation purposes, on-road fitness and health programs, and advanced mechanical competencies
g This study evaluated early pilot Austcycle courses and was consistent with Austcycle Level 1 and 2 (C. Rissel, personal communication, Oct 23, 2017)
h Transport for London provides funds to London boroughs to provide training to anyone who lives, works, or studies in their borough. For further details, we contacted Transport for London staff and learned that individual boroughs determine how to best spend funds. The format and duration of trainings were highly customizable, for example, training could be obtained in group or one to one sessions, for general or specific populations, and the number of sessions could vary, although sessions were a minimum of two hours in duration (L. Mountford, personal communication, Oct 25, 2017)

2.3.6. Descriptions of intervention behaviour change techniques

Only three studies (Ducheyne et al., 2014; van Lierop et al., 2016; Zander et al., 2013) provided sufficient detail to determine behavior change techniques from study descriptions. For other studies, authors obtained intervention training guides (Hatfield et al., 2015; Johnson and Margolis, 2013; Jones, 2017; Rissel and Watkins, 2014; Transport for London, 2017, 2016) or contacted study authors for more information (Telfer et al., 2006). We could not obtain further information on two studies (Groesz, 2007; Montenegro, 2015).

Table 2.6 Behaviour change techniques (BCTs) used in the bicycle skills training interventions

Author, Year	1.1 Goal setting	1.2 Problem solving	3.1 Social support (unspecified)	3.2 Social support (practical)	4.1 instruction on how to perform the behaviour	5.1 Information about health consequences	6.1 Demonstration of the behaviour	6.2 Social comparison	7.7 Exposure	8.1 Behavioural practice	8.7 Graded tasks	9.1 Credible source	10.3 Non-specific reward
Adult Studies													
Johnson & Margolis, 2013[a]	X[c]	X[c]			X	X[d]	X		X[d]	X	X		
Rissel & Watkins, 2014[a]					X	X	X		X[c]	X	X		
Telfer et al., 2006[b]					X	X	X			X	X		
TfL Report, 2016[a]	X[c]	X[c]			X	X[d]	X		X[d]	X	X		
TfL Report, 2017[a]	X[c]	X[c]			X	X[d]	X		X[d]	X	X		
Zander et al., 2013			X	X	X		X			X		X	
Child Studies													
Ducheyne et al., 2014					X		X			X			
Groesz, 2007					X	X	X	X[e]		X			X[e]
Hatfield, 2015a					X	X	X		X	X	X		
Jones, 2017 a					X	X	X		X	X	X		
Montenegro, 2015					X					X		X	
van Lierop et al., 2016					X	X	X		X	X	X		

[a] BCT content obtained through training manual
[b] BCT content confirmed with study author
X[c]=offered in Level 3 only
X[d]=offered in Level 2 & 3 only
X[e]=part of intervention design but not uniformly implemented

Table 2.6 documents behaviour change techniques (BCTs) (Michie et al., 2013) used in interventions. All interventions used the techniques of instruction on how to perform the behaviour (4.1), and on behavioural practice (8.1). Other common techniques were demonstration of the behaviour (6.1) and information about health consequences (5.1), and then graded tasks (8.7) and exposure (7.7). Goal setting (1.1) and problem solving (1.2) were only explicitly mentioned in the London-based advanced trainings, and only one study mentioned social support (3.1, 3.2). Only the Safe Routes to School intervention was explicit about incorporating encouragement (non-specific reward, 10.3) and changing social norms (social comparison, 6.2) as part of its design. Although this latter intervention was designed to include encouragement aspects such as Bike to School events and classroom competitions, in the actual implementation, encouragement was only implemented at one school (Groesz, 2007).

2.4. Discussion

With the goal of increasing active travel, there is growing interest among practitioners on the impact of bicycle skills training on increasing bicycle participation (Johnson et al., 2016; Johnson and Margolis, 2013; Rissel and Watkins, 2014). Our scoping review found 12 studies that focused on bicycle skills training in children and adults. The impact of bicycle skills training on bicycling frequency varied by study; however, the data does suggest that bicycle training programs can be effective in increasing bicycling levels. Most interventions were also effective in increasing confidence, which could encourage more bicycling. The studies inconsistently reported details about the intervention theory, context, and content. However, these details are crucial to assess the effectiveness of the intervention and its generalizability to other settings.

Almost all studies reported that bicycle skills training had some impact on increasing bicycling among participants. Of the 10 studies that specifically assessed bicycling for transportation, six found that bicycling to work or school increased after participating in an intervention. A higher proportion of adult studies (i.e., three of four) found increases in transportation bicycling than children studies (three of six). This trend is strengthened by the findings of a recent New Zealand children study (published in early 2018 after our literature search) which also found small but insignificant increases in bicycling to school post-intervention (Mandic et al., 2018). There are important

distinctions to consider when comparing adult and children transportation bicycling. Adult participants self-select to attend a bicycling skills training, possibly because they are already motivated to increase bicycling (Garrard, 2015), whereas all children at schools participate. Furthermore, the determinants of active travel by bicycle between children and adults differ. For example, children's bicycling to school is also determined by parental attitudes and household travel schedules (Ahern et al., 2017; Mammen et al., 2012; McMillan, 2007). For this reason, some studies included in our review recommend that interventions to increase school active travel need to also directly target parents (Ducheyne et al., 2014; Groesz, 2007; Jones, 2017). Children's bicycling may also be shaped by policies specifying at which age children are allowed to use the bicycle unaccompanied (Shaw et al., 2015).

Half of the studies included subgroup analyses which looked at whether training programs had different effects by bicycling experience, gender, or age. Increasing overall bicycling rates in cities will require more people to begin bicycling, and women are an important target as there is a gender gap in bicycling participation rates (Mitra et al., 2016; Sahlqvist and Heesch, 2012). The review found not only that women tend to be overrepresented in bicycle skills training, but early data from one study suggests that training can narrow the participation gender gap (Transport for London, 2016). Amongst children, one study indicates that girls' bicycling may benefit from sustained encouragement, and bicycle skills training may have a greater impact delivered to children before the teen years (Jones, 2017). This finding aligns with other studies that have found gender differences in bicycling begin as early as the teen years (Emond and Handy, 2012; Handy, 2014; Teyhan et al., 2016; Wittmann et al., 2015). This suggests that not only is earlier delivery more effective, but warrants more study on the gendered longer-term impacts of bicycle training. It also signals that interventions should address gendered barriers and facilitators of bicycling for teen and adult women.

In studies with longer follow-ups or more time points, findings suggest that the impact of bicycling skills training on bicycling frequency is not always maintained, but that increases reported immediately post-intervention declined with time (Hatfield et al., 2015; Jones, 2017; Rissel and Watkins, 2014). To help sustain behaviour change, some study authors recommend that bicycle skills training could be followed by post-training support to ensure that participants consolidate the skills and confidence gained during the intervention (Hatfield et al., 2015; Jones, 2017). It may also be important to examine

the factors influencing the maintenance of bicycling over time, for example, distance to destination, or participant perceptions about convenience of bicycling (Panter et al., 2013a, 2013b). The literature on behaviour change maintenance suggests that interventions be coupled with broader changes to social and physical environments to sustain long-term effects (Kwasnicka et al., 2016; Ory et al., 2010).

Our review examined associations between intervention theory, context, content, and changes in bicycling frequency. The use of theory has been advocated to aid both intervention design and evaluation. Theory aids researchers to measure and describe pathways of behaviour change (Bartholomew and Mullen, 2011), and theory can also help explain why some interventions work in certain settings and not others (Howarth et al., 2016). Theory explicitly identifies what the core intervention components and causal mechanisms of change are thought to be and how the intervention intends to achieve the desired behaviour change (Davis et al., 2015; Kok et al., 2016; Rothman, 2004). Only one of the studies explicitly described underpinning theory, conceptual models, or mechanisms of change; a finding echoed in other active travel reviews (Chillón et al., 2011). However, most studies did name individual-level determinants of bicycling (e.g., confidence, attitudes, safety knowledge, etc.) and measured these, which implies that interventions were based on implicit assumptions about how the program was expected to achieve its objectives. Without explicit theory, we were unable to gain insight as to why only certain behaviour determinants were targeted in the intervention, and how this may have limited the intervention's effectiveness.

Our scoping review found that context was described in half the articles. Context descriptions are essential for understanding why and for whom interventions are effective, and are needed to replicate and build on research findings (Shoveller et al., 2016). Researchers are urged to report more thoroughly on the context of interventions, yet given the cursory treatment of context in many studies it would appear that defining and describing context is a challenge. This is possibly due to the broad range of how context is defined and what can be considered as relevant (Datta and Petticrew, 2013; Howarth et al., 2016; May et al., 2016; Pfadenhauer et al., 2015). To aid context description, Pfadenhauer et al (2017) suggest reporting context at different scales (from local community to national to international) in up to seven domains, of which we assessed the three that have most often appeared in the bicycling literature: political, geographical, sociocultural context. We looked for mention of government policies to

encourage bicycling; characteristics of the built environment to encourage bicycling (specifically investment in bicycling infrastructure); and population bicycling prevalence as a proxy for social norms of the acceptability of bicycling. We recommend study authors report more details on at least these three contextual elements relevant to active travel behaviour change. Our bicycling prevalence measure is possibly too simplistic for some. More thorough description of sociocultural context includes discourses, meanings, and norms of bicycling (Aldred and Jungnickel, 2014; Nettleton and Green, 2014; Sherwin et al., 2014). Other researchers also recommend reporting socio-spatial information such as density, land use diversity, and demographic characteristics of intervention areas (Harms et al., 2016). Study authors could also describe other known determinants of bicycling, such as topography. Bicycle skills trainings target individual-level predictors of behaviour such as skills, confidence, knowledge, and attitudes, but these are also shaped by contextual elements (such as cultural or legal standards for children's independent mobility, or societal perceptions on using bicycles for daily travel) which in turn influence how easily participants are able to shift and sustain behaviour.

Encouraging active travel by bicycle entails targeting determinants beyond the individual level. Bicycling is sensitive to context and practitioners must consider place-based characteristics such as policy, infrastructure, or bicycle culture. Several study authors in our review commented that bicycle skills training needs to be part of a coordinated and multi-faceted approach to encourage bicycling (Ducheyne et al., 2014; Jones, 2017; Rissel and Watkins, 2014; Telfer et al., 2006). Experts have suggested that infrastructure and training can act synergistically and have recommended comprehensive packages of integrated and complementary interventions to boost bicycling (Dill et al., 2014; Pucher et al., 2011, 2010; Pucher and Buehler, 2009; Thigpen et al., 2015). Such packages include changes to the physical and social environment (contexts) through bicycle infrastructure, policies, and promotion (Kandt et al., 2015). In our review, four bicycle skills training interventions were described as part of a comprehensive package undertaken by government where policies and infrastructure to promote active travel were supplemented with bicycle skills training. These were also interventions that showed increased bicycling among participants.

We described bicycle skills training intervention content by collating program activities and delivery details across studies and by coding for behaviour change techniques (BCTs). In the BCTs we were able to code, the most commonly used in

bicycle skills training interventions were behavioural practice, instruction on how to perform the behaviour, demonstration of the behaviour, information about health consequences, graded tasks, and exposure. We did not find any other reviews on BCTs specific to bicycling. However, a few cover walking and cycling, or just walking. Bird et al (2013) found that for walking and bicycling interventions in adults, the most effective active travel interventions tended to include the BCTs of feedback and monitoring, and goals and planning (Bird et al., 2013). A review of walking interventions among children and adolescents found had the same BCTs were associated with effective programs, as well as social support, and repetition and substitution (Carlin et al., 2016). While BCTs effective in increasing walking may not be the same as for increasing bicycling (for example, the strong emphasis on behavioural practice may not be necessary in walking interventions), and it is also possible that the behaviour change techniques for increasing bicycling in different populations (such as children and adults) may differ. To facilitate behaviour change, interventions must have clear aims (e.g., to specifically increase bicycling to school, not just to increase bicycling skills). For example, the authors of one study that failed to increase bicycling to school noted that to influence mode shift, their intervention might have incorporated different strategies to target different determinants (Ducheyne et al., 2014).

The small number of studies returned by our search is not an unexpected finding: overall, there appear to be few studies assessing adult bicycle skills training, and even fewer studies that measured bicycling frequency as an outcome in either adults or children. This paucity has been noted by other researchers (Pucher et al., 2011; Richmond et al., 2013). In many countries, bicycle skills training tend to be delivered by bicycling advocacy organizations, where funding may be directed toward service delivery rather than evaluation. Furthermore, with no universal school-based bicycle skills training delivered to children in most countries, systematic data collection or evaluation is unlikely to occur.

2.4.1. Strengths and limitations

This scoping review addressed an evidence gap on the impact of bicycle skills training on bicycling frequency (Goodman et al., 2016; Johnson et al., 2016), and further, extracted information on intervention theory, context, and content to describe variation in bicycling change within and between studies. Another strength of our study was the

inclusion of grey literature, which gave us access to a broader range of evaluations that have been conducted and enabled us to include studies that added new information on gender-specific changes in bicycling. Our review looked at studies incorporating a pre- and post-test design so we could assess individual-level changes in bicycling frequency. This complements other literature that examines people's narratives of participating in a bicycle skills training program. One challenge we faced was the diverse ways that researchers measure bicycle frequency, making it challenging to directly compare intervention effects. Such heterogeneity in bicycling research has been noted elsewhere (Bird et al., 2013; Ogilvie et al., 2004; Pucher et al., 2010; Stewart et al., 2015; Yang et al., 2010). Another challenge was that we did not have sufficient data to code BCTs in all studies, despite contacting authors of the articles. With this lack of data, we are unable to attribute the impact of individual BCTs to bicycling outcomes. Furthermore, to respond to the transportation targets set by many cities, we restricted our search strategy to interventions encouraging *transportation* bicycling rather than bicycling more broadly (limiting studies using stationary or pool/aqua bicycles, or studies on elite athletes). Finally, we limited our search to English publications.

2.4.2. Implications for policy and practice

This review suggests that bicycle skills training may be a useful strategy for increasing bicycling participation. Specific opportunities to increase bicycling may be to target new and infrequent cyclists, especially women. Children are also an important target population, and training may have larger impact when delivered before the teen years. Additionally, interventions may benefit from incorporating follow-up support for trainees to help sustain their bicycling. Local governments may see maximum bicycling increases by designing a comprehensive package of interventions that includes supportive infrastructure and bicycle skills training, among other promotional efforts.

To generate a more rigorous evidence base on the sustainability of any impacts, a methodological recommendation is to include multiple follow-up measures to assess bicycling trajectories, as well as adequate follow-up periods to allow changes in bicycling to occur. A second methodological recommendation is to incorporate comparison populations (i.e., people who do not receive the intervention) to control for weather/seasonality, children's maturation, or other factors affecting cycling (Harris et al., 2006). A third recommendation, to enable comparison of effect sizes between

studies (e.g., using Cohen's d), is for study authors to report standard deviations for proportions.

Future training interventions should consider reporting explicitly on theory, context, and content. Numerous tools or frameworks such as the Theoretical Domains Framework/Behaviour Change Wheel (Michie et al., 2011; see also www.behaviourchangewheel.com), Intervention Mapping (Kok et al., 2016), or realist evaluation (Pawson and Tilley, 1997) have been developed to support theory-driven approaches. A theory-driven approach to intervention design and evaluation explicitly maps out the process of how changes in bicycling frequency will be achieved through bicycle skills training, and this can help identify the appropriate content and behaviour change techniques to be applied. This may be especially salient for addressing barriers that go beyond skills-based consideration. A theory-driven approach can also account for the ways in which bicycle skills training interacts with its contexts. This helps improve the quality of bicycle skills training (e.g., to be more responsive to the needs of target populations); explain why changes are higher or low than expected; assist with scale-up; and inform policy-makers what further actions need to be taken to enable people to adopt bicycling.

2.5. Conclusions

This is the first review that examines bicycle skills training and changes in bicycling frequency. The main finding is that bicycle skills training is generally associated with increased bicycling, but the number of studies are small and of mixed quality. Future studies should also report adequate details about the intervention theory, context, and content, so that it may be generalizable for use in other settings. Such reporting would also allow for better implementation in policy and practice. Further, studies need to incorporate more rigorous study designs that include multiple points of follow-up, and with comparison groups if possible. Subgroup analysis between genders, non-bicyclists and current bicyclists, content (e.g., off- and on-bike components such as road-rides), or programs implemented in different contexts may further advance insights into for whom training programs are most effective in terms of increasing bicycling. Such details are important to guide other practitioners on training design and implementation.

Chapter 3.

Effectiveness of a bicycle skills training intervention on increasing bicycling and confidence: A longitudinal quasi-experimental study

Abstract

Background: Bicycling shows potential for addressing both health and transportation challenges. One strategy to encourage more people to bicycle is skills training courses; however, there is limited evidence for their effectiveness, especially longer-term. We assessed the impact of adult bicycle skills training programs offered in Metro Vancouver, Canada, using a longitudinal, quasi-experimental study design to compare changes in bicycling and confidence over time between course participants and a comparison group.

Methods: Bicycle courses delivered by accredited instructors, 2 to 4.5 hours in duration, aimed to increase participant comfort level to ride on residential and urban streets through teaching in-person and on-road traffic handling skills. We collected data in 2016 and 2017 through online questionnaires at baseline, 1, 3, and 12 months post-course, and used mixed models to assess changes.

Results: We enrolled 135 course and 43 comparison participants. At baseline, 32 participants reported no bicycling; 18 started bicycling during the study. Adjusted models did not find different trajectories for course and comparison participants for bicycling overall (RR=0.99, 95% CI: 0.96, 1.02) or for any specific purpose (commuting RR=1.03, 95% CI: 0.99, 1.08; errands RR=0.97, 95% CI: 0.93, 1.01; leisure RR=0.96, 95% CI: 0.93, 1.00), or for confidence.

Conclusion: Bicycle courses aim to address individual-level barriers to bicycling, such as skills, knowledge, and confidence, but such courses may not be enough to overcome other barriers. Bicycle courses should be combined with environmental and other means of support to achieve greater impact on bicycling.

3.1. Background

Active travel (walking, bicycling, and relatedly public transport) has multiple benefits, including environmental, congestion, and health benefits (Götschi et al., 2016; Zahabi et al., 2016). For these reasons, increasing the number of people using bicycles for transportation has become a public health and sustainability goal. Bicycling behaviours depend on multiple intersecting variables, such as sociodemographic, attitudinal, and environmental characteristics that vary by trip purpose and throughout the life course (Buehler and Pucher, 2012; Chatterjee et al., 2013; Heinen et al., 2010; Willis et al., 2015). Notably, studies have found that safety concerns about sharing the road with motorized vehicles pose a major barrier in people's decisions about whether to bicycle (Fishman et al., 2012), as do related aspects such as confidence (Willis et al., 2015; Xing et al., 2010).

Many bicycle skills training courses ("courses") aim to enhance confidence and bicycling skills through education and opportunities to practice (Hawley and Mackie, 2015; Johnson and Margolis, 2013; Rissel and Watkins, 2014; Rowe et al., 2016; Telfer et al., 2006; Zander et al., 2013). Countries with low bicycling prevalence (such as Canada and the US) often lack universal school-based bicycling education, meaning the majority of the population has never received formal instruction for bicycling. Courses can address individual-level barriers such as low confidence, not knowing rules, or insufficient bicycle handling skills (Handy et al., 2014), although cannot directly modify systemic barriers such as distance, infrastructure, or weather. Bicycle courses designed for adults differ from children's courses in several aspects: typically children's courses are delivered in school settings over multiple sessions, whereas adults voluntarily choose to enroll in a course. Training programs for children may be even more variable in format than those for adults. For example, children's training programs in Canadian cities may be school-based (ranging from 1-13 weeks), or outside of schools in single day workshops to multi-day camps. The heterogeneity of programing challenges comparisons. However, for courses teaching urban shared-road safety skills, course content for older children and adults may be similar (Sersli et al., 2019a).

There are few studies on the effectiveness of bicycle courses for adults (Johnson and Margolis, 2013; Pucher et al., 2010) (Table 3.1). Table 3.1 summarizes published literature on adult bicycle courses from a recent scoping review on pre-post studies

(Sersli et al., 2019a), supplemented with evidence derived from different study designs. These ten studies varied in focus, design, and quality. Women (Hawley and Mackie, 2015; Johnson and Margolis, 2013; Rissel and Watkins, 2014; Telfer et al., 2006; Transport for London, 2017, 2016; van der Kloof et al., 2014) and people new to bicycling (Hawley and Mackie, 2015; Johnson and Margolis, 2013; Transport for London, 2017; van der Kloof et al., 2014) were well represented in courses. Outcomes varied: some studies measured only overall bicycling (Hawley and Mackie, 2015; Rissel and Watkins, 2014; Zander et al., 2013) while others measured bicycling for a specific trip purpose (Bernstein et al., 2017; Transport for London, 2017, 2016). Follow up periods ranged from immediately post-course to one or more years, and some studies had large losses to follow up. Only one study (a trial where 21 participants were given bicycles and participated in a course) had a comparison group (Bernstein et al., 2017). Three studies were from the same city (London) (Johnson and Margolis, 2013; Transport for London, 2017, 2016).While the small number and heterogeneity of studies makes it difficult to draw conclusive statements, the sparse evidence available suggests that training may encourage bicycling. Results also show that confidence increases after course participation (Johnson and Margolis, 2013; Rissel and Watkins, 2014; Telfer et al., 2006; Transport for London, 2017, 2016), as does recreational (leisure) bicycling. Increases in transportation bicycling uptake have been more modest.

Given the need for guidance on effective interventions to encourage bicycling, we partnered with a bicycle advocacy organization delivering bicycling courses to adults in Metro Vancouver to assess the impact that courses have on bicycling uptake. Our aim was to compare changes over one year in bicycling overall, in transportation-specific (commuting, errands) and leisure bicycling, and in confidence, between course participants and a comparison group.

Table 3.1 Summary of adult bicycle skills training studies

Author, Year, Country	Publication type	Study design(s); sampling strategy [a], sample size	Follow up after training	Bicycling frequency measures	Direction of change in bicycle frequency relative to baseline	Course description [b] (name; road ride component; group or 1:1 format; duration)
Bernstein et al., 2017, US	Peer-reviewed publication	Pre-post questionnaire; randomized control trial; pre n=38, 3 month n=26, 5 month n=26	Immediately after program delivery (3 months from baseline); 5 months from baseline	# days/previous week bicycling for 1) commuting, 2) errands, 3) leisure	1) no change 2) increase 3) increase	Road ride; 10 group sessions over 12 weeks
Hawley & Mackie, 2015, NZ	Evaluation report	Post-intervention retrospective questionnaire; n=86	unclear	# days/month bicycled before course compared to # days/previous month bicycled	Increase	Beginner: no road ride Cycling on the road: road ride
Johnson & Margolis, 2013, UK	Peer-reviewed publication	Pre-post questionnaire; pre n=471, 3 month n=130	3 months	1) # days/previous week bicycling >30 minutes; 2) # days/previous week bicycled to work	1) increase 2) increase	Bikeability [c]; road ride for levels 2 & 3; 1:1 sessions; up to 4 hrs (4 x 1 hr sessions)
Rissel & Watkins, 2014, AU	Peer-reviewed publication	Pre-post questionnaire; random sampling; pre n=4145, 3 month n=423, 12 month n=125	3 months; 12 months	1) bicycle in previous week (y/n) 2) bicycle in previous month (y/n)	1) increase 2) increase	Austcycle [d]; road ride for levels 2 & 3
Rowe et al., 2016, AU	Peer-reviewed publication	Two retrospective interviews (the first shortly after intervention and second a few months later); n=33	3-5 months	Not reported	Not reported	Austcycle [d]; road ride for levels 2 & 3

Author, Year, Country	Publication type	Study design(s); sampling strategy [a], sample size	Follow up after training	Bicycling frequency measures	Direction of change in bicycle frequency relative to baseline	Course description [b] (name; road ride component; group or 1:1 format; duration)
Telfer et al., 2006, AU	Peer-reviewed publication	Pre-post questionnaire and interview; pre n=113, 2 month n=105	2 months	1) # days/previous week bicycling; 2) mins/previous week bicycling; 3) # days/previous week bicycling to work	1) no change 2) increase 3) no change	Based on Austcycle [d]; road ride for level 2; group sessions; 6 hr (2 x 3 hr sessions)
Transport for London, 2016, UK	Evaluation report	Pre-post questionnaire; pre n=800, 3 month n=258, 12 month n=101	3 months; 12 months	# days bicycling for 1) commuting, 2) errands, 3) leisure	1) increase 2) increase 3) increase	Bikeability [c]; road ride for levels 2 & 3; group or 1:1 format
Transport for London, 2017, UK	Evaluation report	Pre-post questionnaire; pre n=724, 3 month n=220, 12 month n=32	3 months; 12 months	# days bicycling for 1) commuting, 2) errands, 3) leisure	1) increase 2) increase 3) increase	Bikeability [c]; road ride for levels 2 & 3; group or 1:1 format
van der Kloof et al., 2014, NL	Peer-reviewed publication	Pre-post questionnaire, n=83 Retrospective interview, n=19	Immediately after program delivery Unclear; up to 4 years	Not reported Not reported	Not reported Not reported	10-15 group sessions lasting 1 hr to ½ day
Zander et al., 2013, AU	Peer-reviewed publication	Pre-post interviews; pre n=17, immediately after program delivery n=11	Immediately after program delivery	Meet 2 hr/week bicycling target (y/n)	Increase	Road ride; group session; 4.5 hr

[a] Sampling strategy included if described in study

[b] Course name, road ride component, group or 1:1 delivery format, or course duration only included if described in study. All courses included time on the bicycle. Some courses follow nationally prescribed curriculum (Austcycle, Bikeability).

[c] Bikeability offers tiered training courses to address progressive ability level

[d] Austcycle offers tiered training courses to address progressive ability level

3.2. Methods

3.2.1. Setting

Metro Vancouver is comprised of 22 municipalities with diverse urban form and transportation infrastructure. Its mild climate is conducive to year-round bicycling. The bicycle route network is relatively dense within the city of Vancouver, more so than in the surrounding municipalities. The city of Vancouver's network consists mainly of local street bikeways (shared roadways along local streets, typically traffic-calmed) (Winters and Zanotto, 2019). Bicycle journey-to-work mode share in Metro Vancouver is 2.3%, but 6.1% within the city of Vancouver itself, higher than other large Canadian cities such as Toronto (2.7%) or Montreal (3.9%) (Statistics Canada, 2017b, 2017c, 2017d).

3.2.2. Intervention: Adult bicycle skills training courses

In 2016 and 2017, 28 bicycle courses were offered through a bicycling advocacy organization during the summer months (late April-early October), in the city of Vancouver (n=23 courses) or neighbouring municipalities (n=5). Courses were either 2 or 4.5 hours in duration, consisted of one session, and delivered by accredited instructors with an instructor-student ratio of 1:6. Courses were promoted in a variety of ways: posters at libraries, community centres, bike shops, cafes; during events such as Bike to Work Week and at Car Free Days; social media posts including paid Facebook ads; and the advocacy organization's own communications channels and website. Participants registered for courses online and paid a nominal course fee ($10 to $45).

Designed by a bicycling advocacy organization, the bicycle courses addressed bicycling in urban environments on various route types, including on streets shared with cars. Participants were expected to have at least some level of bicycle proficiency (courses were advertised "for anyone who can already ride a bike"). Courses contained: 1) a theoretical component involving slides, and a learning environment encouraging classroom questions; 2) the distribution of written resources (such as municipal bicycling maps); and 3) a bicycle riding session involving practice of bicycling technique in traffic-free areas and on streets with quiet to moderate traffic.

The current 4.5 hour course was designed by the advocacy organization in 2012, based on other bicycling education curricula, and in consultation with local bicycle instruction experts. The shortened 2 hour launched in 2016 in response to participant requests for a condensed course. The shorter course has less time for classroom discussion, and a shortened bicycle riding session. The theoretical content and written resources are identical. The courses undergo annual updates to remain current and effective in the Metro Vancouver context. Both courses aim to increase participants' knowledge of safe cycling practices, and to build confidence riding in all traffic situations in urban environments.

To describe course content we used a taxonomy of Behaviour Change Techniques (BCTs) developed by Michie and colleagues (Michie et al., 2013). BCTs can identify the “active ingredients” of interventions and were developed to improve the clarity of intervention descriptions. Table 3.2 outlines the BCTs used in courses, including instruction, information, opportunities to practice skills, and opportunities to practice skills in progressively more complex street environments.

In absence of an explicit program theory of how the course leads to changes in confidence and bicycling, we mapped the BCTs used in the courses back to the Theoretical Domains Framework and corresponding Capability, Opportunity and Motivation-Behaviour (COM-B) system of behaviour change (Cane et al., 2015). Both the Theoretical Domains Framework and COM-B were developed as resources to guide intervention development. Whereas the Theoretical Domains Framework consists of dozens of theoretical constructs from multiple behaviour change theories sorted into 14 domains, the COM-B system is even more streamlined, hypothesizing behaviour change in terms of psychological and physical capability, physical and social opportunity, and reflective and unconscious motivational barriers and enablers (Atkins et al., 2017; Cane et al., 2012).

Table 3.2 Behaviour change techniques (BCTs) used in bicycle skills training intervention

BCT #	BCT description	Course content example	Theoretical Domains Framework	Capability, Opportunity and Motivation-Behaviour (COM-B)
4.1	Instruction on how to perform the behaviour	Visual and verbal instruction about observing traffic rules as a bicyclist (e.g., road position, stop signs, left-turns), route-planning (using paper and online bicycle maps), using public transit with bicycle	Knowledge Skills Belief about capability	Capability Capability Motivation
5.1	Information about health consequences	Visual and verbal information about traffic rules as applying to bicyclists, such as bicycling distance from parked cars, vehicular left-turns	Knowledge Belief about consequences	Capability Motivation
6.1	Demonstration of the behaviour	Instructors demonstrate emergency braking, shoulder-checking, hand-signals, vehicular left-turns	Skills Belief about capability	Capability Motivation
8.1	Behavioural practice/rehearsal	In a traffic-free area, participants practice bicycle skills demonstrated by instructors. On streets with quiet/moderate traffic (i.e., on local street bikeways), participants practice bicycle skills such as lane position and/or distance from parked cars, 4-way stops, vehicular left turns.	Skills Belief about capability	Capability Motivation
8.7	Graded tasks	Participants practice bicycle skills in traffic-free areas, then quiet streets (i.e., local street bikeways), then to progressively more complex street environments with moderate traffic, cumulating with a short ride on an arterial road.	Skills Belief about capability	Capability Motivation

3.2.3. Study design

We used a longitudinal, quasi-experimental study design. We recruited registered participants in advance through email, and in person on the day of their course. We used two recruitment methods as many participants reported having not received an advance email invitation to the study. A research assistant recruited 50 participants in person at courses. Participants were eligible if they were aged 19 or older and had sufficient English (self-assessed) to complete the surveys (English-language only). They were sent a web link to complete baseline surveys before or within 6 hours of completing their

course. Participants who cancelled or missed their course were recruited for the comparison group. Comparison participants were screened to ensure they had not attended other courses that summer. All participants were offered $10 gift card compensation for completed questionnaires.

Questionnaires included bicycling behaviors and attitudes, neighborhood perceptions, individual and household demographics, and residential postal code. Data was collected across four time points: baseline, 1, 3, and 12 months follow up. Our interest to assess longer term changes in bicycling combined with seasonal variations in a rainy climate suggested 12 months to be an appropriate follow up. The Simon Fraser University Research Ethics Board (2015s0220) granted ethics approval for this study.

3.2.4. Measures

3.2.4.1 Outcome: Bicycling

We assessed bicycling for three purposes: for commuting (i.e., “to work or school”), for errands (i.e., “for errands or shopping”), and for leisure (i.e., “outdoors for fun or exercise”). For each purpose, participants reported how many days in the past month they bicycled, from a set of discrete categories (e.g., 1-3 days in the past month). The midpoint of each range was used to calculate the number of days of per month. We calculated days of overall bicycling by summing the days of commuting, errands, and leisure for each participant.

3.2.4.2 Outcome: Confidence

We used three items for confidence that relate to aspects targeted during the course. Participants were asked to rate their degree of confidence based on the following: (1) knowing how to ride a bicycle; (2) bicycling on a street with cars; (3) bicycling on a path away from traffic; (4) using a map to select a route; (5) bicycling for daily travel; (6) knowing where safe routes are located; (7) bicycling with things to carry; (8) bicycling in rainy weather; and (9) bicycling with children For analysis, we categorized the five-point Likert responses as confident (“strongly agree”, “agree”) or not confident (“neither agree nor disagree”, “disagree,” and “strongly disagree”).

3.2.4.3 Primary variables

To assess the effect of the course over time, we treated time as a continuous variable (0, 1, 3, 12 months). We used a treatment variable to indicate if participants were in the intervention (attended the course) or comparison group (signed up but did not attend the course). The interaction term (time*treatment) was our primary coefficient of interest, as it indicates the differential change across time in bicycling for intervention and comparison participants.

3.2.4.4 Covariates

Demographic information was collected at baseline. Participants were asked to report their gender, age, education, ethnicity, number of years lived in Canada, income, and number of children under 17 years in the household. Additional information was collected at each measurement period, including access to a bicycle, access to a motor vehicle, employment and student status, and residential postal code. In models we included the following covariates: age (< 40 years versus ≥ 40 years); city (Vancouver, other); Bike Score® (a composite measure based density of bike lanes, hilliness, destinations, and road connectivity) (Winters et al., 2016)) at home residence. We also include seasonality, as participants enrolled in courses throughout the summer months, meaning that those who enrolled in a bicycle course in August or later had their 1 and/or 3 month follow up measures during or after October, when the weather in Metro Vancouver becomes cooler and rainier. To control for seasonality, we used the season of the course (“April-July” or “August-October”).

3.2.5. Statistical analyses

We used descriptive statistics to present demographic characteristics of the treatment groups at baseline, and we assessed differences in factors related to bicycling between treatment groups using t-tests for continuous variables and chi-square analyses for categorical variables. To control for initial group differences, we included characteristics that were significant at $p<0.05$ as covariates in our adjusted model, plus gender.

To account for dependence of multiple measures and variability between individuals we used mixed effects modelling where the four observations (0, 1, 3, 12

months) were nested within participants, and participant treated as a random effect. We used negative binomial mixed models to assess changes in bicycling (days per month) and logistic mixed models to assess changes in confidence over time.

To select parsimonious models, we used a multi-phase process. We started with an unconditional model without explanatory variables. We next introduced the primary variables (time, treatment) for a two-way interaction of time by treatment group, and then added covariates to adjust the model. We determined the optimal random effects structure by using maximum likelihood estimation to fit and compare unconditional, base, and adjusted models, using Akaike's information criterion (AIC) to identify the best-fitting models. We also used AIC to compare models fit with Poisson and negative binomial distributions. All statistical analyses were conducted using R studio 1.1.447 using the glmmTMB and lme4 packages (Bates et al., 2014; Magnusson et al., 2017).

3.3. Results

3.3.1. Sample characteristics

During the 2016 and 2017 season, 349 people registered in 28 adult bicycle training courses (Figure 3.1). A total of 63 were ineligible (56 under 19 years of age, 7 with low English). Of 286 eligible students, 178 enrolled in our study (response rate 62%). Table 3.3 shows participant demographics at baseline. The majority of participants were women, university-educated, had access to cars, and were living in households without children. Of the 178 participants, 135 (76%) were in the intervention group and 43 (24%) in the comparison group. Of the 135 intervention participants, 27 (20%) took the shorter 2 hour course. Loss to follow up over 12 months was low (<1%) with no loss in the comparison group. Baseline differences between the intervention and comparison groups were age, city of residence, and season of study enrollment.

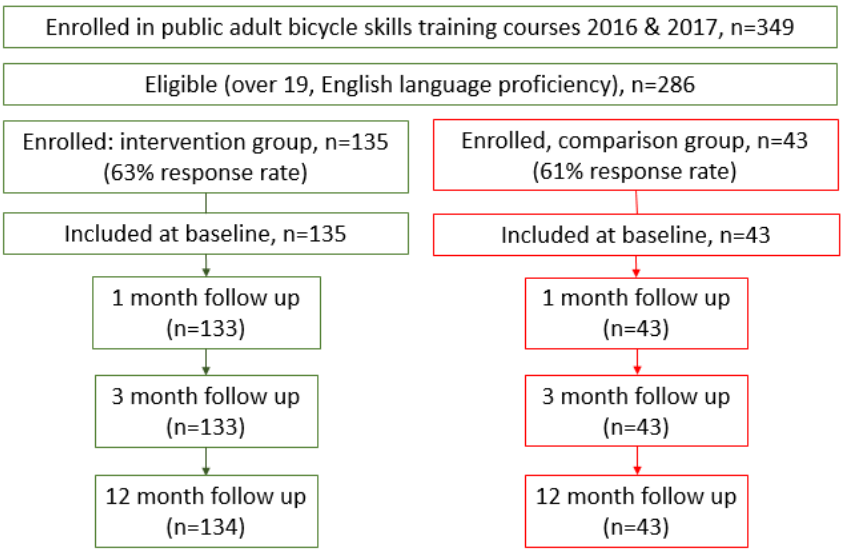

Figure 3.1 Summary of recruitment and study participation

3.3.2. Changes in bicycling participation, frequency, and confidence

We examined the proportion of participants not bicycling at baseline (Table 3.3). At baseline, 18% (32/178) of participants reported zero days of bicycling in the past month. Of these, 18 (13 intervention, 5 comparison) started bicycling during the study, whereas 14 (7 intervention, 7 comparison) did not bicycle at all during the entire study duration. When we examined bicycling by trip purpose at baseline, 57% (90/157) participants reported zero days of bicycling for commuting; 53.9% (96/178) for errands; 32% (57/178) for leisure. When participants did use bicycles for commuting, they did so often: the majority (70% or 47/67) commute bicycled more than once per week at baseline.

We examined the proportion of participants that said they felt confident for each of the nine confidence measures (Table 3.3). At baseline, there were no significant differences between intervention and comparison groups. Most of participants reported feeling confident knowing to ride a bicycle (97%) and riding a bicycle safely on a path away from traffic (92%). Participants were least confident travelling by bicycle with things to carry (39%), in rainy weather (31%), or with children (15%).

Table 3.3 Characteristics of intervention and comparison participants at baseline.

Characteristics at baseline		Intervention (n=135) n (%)	Comparison (n=43) n (%)	P-value [a,b]
Demographic				
Gender (women)		93 (68.9%)	33 (76.7%)	0.30[a]
Age (under 40 years old)		59 (43.7%)	27 (62.8%)	0.04[a]
Education, graduated university		104 (77.0%)	31 (72.1%)	0.60[a]
Household income	Under $50,000	30 (22.2%)	12 (27.9%)	0.80[a]
	$50,000-$100,000	52 (38.5%)	15 (34.9%)	
	Over $100,000	22 (16.3%)	8 (18.6%)	
Settlement status	In Canada < 5 years	17 (12.6%)	7 (16.3%)	0.50[a]
	In Canada > 5 years	50 (37.0%)	12 (27.9%)	
	Born in Canada	68 (50.4%)	24 (55.8%)	
Ethnicity/race (self-identify as White)		67 (49.6%)	20 (46.5%)	0.90[a]
Employment, at least part-time		105 (77.8%)	37 (86.0%)	0.30[a]
Children <17 at home (yes)		51 (37.8%)	12 (27.9%)	0.30[a]
Access to bike (yes)		124 (91.9%)	37 (86.0%)	0.40[a]
Access to car (yes)		106 (78.5%)	34 (79.1%)	1.00[a]
Bike Score® at home residence (mean, SD)		83.5 (19.6)	75.7 (24.8)	0.10[b]
Residing in Vancouver (yes)		90 (66.7%)	21 (48.8%)	0.05[a]
Season of study enrollment (April-July)		93 (68.9%)	11 (25.6%)	<0.01[a]
Bicycle frequency [c]				
Bicycled zero days past month, any purpose		20 (14.8%)	12 (27.9%)	0.09[a]
Bicycled >5 days past month, any purpose		74 (54.8%)	18 (41.9%)	0.02
Bicycled zero days past month, commuting		66 (57.4%)	24 (57.1%)	1.00[a]
Bicycled >once/week past month, commuting		35 (30.4%)	12 (28.6%)	1.00[a]
Bicycled zero days past month, errands		68 (50.4%)	28 (65.1%)	0.10[a]
Bicycled >once/week past month, errands		17 (12.6%)	5 (11.6%)	1.00[a]
Bicycled zero days past month, leisure		37 (27.4%)	20 (46.5%)	0.03[a]
Bicycled >once/week past month, leisure		21 (15.6%)	3 (7.0%)	0.20
Confidence				
I know how to ride a bicycle, i.e., balance, steer, stop		129 (95.6%)	43 (100%)	0.40[a]
I can ride a bicycle safely on a street with cars		70 (51.9%)	19 (44.2%)	0.50[a]
I can ride a bicycle safely on a path away from traffic		123 (91.1%)	40 (93.0%)	0.90[a]
I can use a map to choose a suitable route for me to bicycle		99 (73.3%)	32 (74.4%)	1.00[a]
To ride a bicycle for daily travel would be easy		59 (43.7%)	18 (41.9%)	1.00[a]
I know where safe bike routes are		76 (56.3%)	23 (53.5%)	0.90[a]
I can travel by bicycle when I have things to carry		54 (40.0%)	16 (37.2%)	0.90[a]

Characteristics at baseline	Intervention (n=135) n (%)	Comparison (n=43) n (%)	P-value [a,b]
I can travel by bicycle in rainy weather	39 (28.9%)	16 (37.2%)	0.30[a]
I can travel by bicycle when I have children with me	16 (11.9%)	7 (16.3%)	0.70[a]

a Chi-square test; b Mann Whitney test

c Only participants working or attending school (n=157) were included in bicycling for commuting; all participants were included in bicycling for any purpose, errands, and leisure

Table 3.4 summarizes bicycle behaviours at each time point. Participants in both groups tended to bicycle most often for commuting (baseline means of 5.1 and 5.0 days/month, respectively), and least often for errands (2.8 and 2.0 days/month). There were no significant differences in frequency of commute and errand bicycling between groups at baseline. At one month follow up, intervention participants increased bicycling after their course for all trip types, whereas comparison participants experienced no increase. For the confidence outcomes intervention participants increased confidence more quickly than comparison participants.

Table 3.4 Bicycling frequency and confidence for intervention and comparison groups at baseline and follow up

Data collection time	Intervention group mean (SD) days/month	Comparison group mean (SD) days/month	P-value [a, c]
Any purpose	Intervention (n=135) [b]	Comparison (n=43) [b]	
Baseline	10.5 (11.9)	9.3 (13.3)	0.20
1 month	12.4 (12.9)	6.7 (10.6)	<0.01
3 months	10.0 (12.0)	5.1 (11.3)	<0.01
12 months	11.3 (12.7)	8.0 (13.1)	0.08
Commuting	Intervention (n=115) [b]	Comparison (n=42) [b]	
Baseline	5.1 (7.7)	5.0 (7.8)	1.00
1 month	6.1 (8.1)	3.5 (6.5)	0.05
3 months	4.8 (7.2)	2.5 (5.8)	0.01
12 months	5.3 (7.4)	3.0 (5.4)	0.10
Errands	Intervention (n=135) [b]	Comparison (n=43) [b]	
Baseline	2.8 (5.2)	2.0 (3.9)	0.20
1 month	3.3 (5.3)	1.3 (2.4)	<0.01
3 months	3.1 (5.4)	1.4 (3.5)	<0.01
12 months	3.0 (5.3)	2.0 (4.6)	0.30
Leisure	Intervention (n=135) [b]	Comparison (n=43) [b]	
Baseline	3.3 (3.8)	2.4 (4.4)	0.04
1 month	4.3 (4.8)	2.1 (3.6)	<0.01
3 months	3.0 (4.4)	1.3 (3.2)	<0.01
12 months	3.7 (4.7)	3.2 (5.1)	0.40
Can ride a bicycle safely on a street with cars	Intervention (n=135) Number, % confident	Comparison (n=43) Number, % confident	
Baseline	70 (51.9%)	19 (44.2%)	0.50

Data collection time	Intervention group mean (SD) days/month	Comparison group mean (SD) days/month	P-value [a, c]
1 month	108 (81.8%)	25 (58.1%)	<0.01
3 months	109 (82.0%)	25 (58.1%)	<0.01
12 month	107 (79.9%)	27 (62.8%)	0.04
Can use a map to choose a suitable route for me to bicycle	Intervention Number, % confident	Comparison Number, % confident	
Baseline	99 (73.3%)	32 (74.4%)	1.00
1 month	116 (88.5%)	28 (65.1%)	<0.01
3 months	122 (91.7%)	29 (67.4%)	<0.01
12 month	122 (91.7%)	32 (74.4%)	0.01
Know where safe bike routes are	Intervention Number, % confident	Comparison Number, % confident	
Baseline	76 (56.3%)	23 (53.5%)	0.90
1 month	108 (81.8%)	24 (55.8%)	<0.01
3 months	113 (85.0%)	22 (51.2%)	<0.01
12 month	105 (78.4%)	27 (62.8%)	0.07

[a] Chi-square test; [c] Mann Whitney test

[b] Only participants working or attending school were included in bicycling for commuting; all participants were included in bicycling for errands and leisure

3.3.3. Regression analysis for bicycling and confidence

We used negative binomial mixed models (Table 3.5) to assess changes in bicycling over time. Time was modelled as a continuous variable across one year; we also modelled time categorically to assess short-term changes (Appendix F). Rate ratios represent the percentage change in the number of days bicycled in the previous month, and the interaction term represents the differential change over time between the intervention and comparison groups. In the adjusted models for overall bicycling, there were no significant interaction or main effects indicating there was no change over time in the number of days per month participants rode bicycles. Likewise, in the adjusted models for commuting and errands there was no change over time in bicycling to work or for errands. We saw that men had higher rates of bicycling overall and to work compared to women, and participants living outside the city of Vancouver had much lower rates of bicycling overall, to work, or using bicycles for errands. Participants registering for courses later in the season had lower rates of overall bicycling.

For leisure bicycling, the models show that at baseline, intervention participants rode more often than comparison group members, although the difference was attenuated when adjusted for gender (RR = 1.75, 95% CI: 1.13, 2.73). Additional tests revealed that intervention participants significantly increased leisure bicycling between

baseline and 1 month follow up (RR = 1.27, 95% CI: 1.05, 1.54), but the overall change between baseline and 12 month follow up was not significant. Men had higher rates of leisure bicycling compared to women.

We used logistic mixed models (Table 3.6) to assess changes in confidence for three aspects of confidence that were targeted during the course. For items, “I can ride a bicycle safely on a street with cars”, “I can use a map to choose a suitable route for me to bike”, and “I know where safe bike routes are”, the interaction term was not significant, meaning the probability of feeling confident for any confidence measure did not differ as a function of being in the intervention or comparison group. Additional post hoc analysis showed no difference in change in bicycling for any trip type between short and long course participants. In terms of confidence change over time, shorter course participants had higher odds of feeling confident in using a map to choose a suitable route than the longer course participants but confidence intervals are wide (OR=3.73, 95% CI: 1.26, 11.07) indicating a larger sample is warranted.

Table 3.5 Negative binomial random intercept models on impact of a bicycle skills training course over one year for bicycling frequency (days per month)

	Overall		*Commuting*		*Errands*		*Leisure*	
	Base	**Adjusted**	**Base**	**Adjusted**	**Base**	**Adjusted**	**Base**	**Adjusted**
Fixed Effects	Rate ratio (95% CI)	Rate ratio (95% CI)	Rate ratio (95% CI)	Rate ratio (95% CI)	Rate ratio (95% CI)	Rate ratio (95% CI)	Rate ratio (95% CI)	Rate ratio (95% CI)
Time[a]	1.01 (0.98 – 1.04)	1.01 (0.99 – 1.04)	0.97 (0.93 – 1.01)	0.98 (0.94 – 1.02)	1.02 (0.99 – 1.06)	1.03 (0.99 – 1.07)	1.04 (1.00 – 1.07)	1.04 (1.00 – 1.07)
Treatment: course[b]	**2.19 (1.42 – 3.39)**	1.41 (0.89 – 2.23)	2 (0.89 – 4.48)	1.04 (0.44 – 2.45)	**2.69 (1.37 – 5.30)**	1.66 (0.80 – 3.43)	**2.24 (1.48 – 3.38)**	**1.75 (1.13 – 2.73)**
Time*treatment[c]	0.99 (0.96 – 1.01)	0.99 (0.96 – 1.02)	1.03 (0.98 – 1.07)	1.03 (0.99 – 1.08)	0.97 (0.93 – 1.01)	0.97 (0.93 – 1.01)	0.96 (0.93 – 1.00)	0.96 (0.93 – 1.00)
Covariates								
Gender: men[d]		**1.82 (1.26 – 2.62)**		**2.93 (1.43 – 5.99)**		1.62 (0.91 – 2.91)		**1.64 (1.17 – 2.29)**
City: outside Vancouver[e]		**0.52 (0.38 – 0.71)**		**0.31 (0.17 – 0.54)**		**0.3 (0.18 – 0.50)**		0.82 (0.61 – 1.12)
Season: Aug-Oct[f]		**0.6 (0.41 – 0.86)**		0.55 (0.27 – 1.12)		0.67 (0.37 – 1.21)		0.71 (0.51 – 1.00)
Age: over 40[g]		1.07 (0.76 – 1.51)		0.92 (0.47 – 1.80)		0.95 (0.55 – 1.65)		1.06 (0.77 – 1.46)
Random Effects								
τ_{00} (Random intercept)	1.17 $_{ID}$	1.00 $_{ID}$	3.82 $_{ID}$	3.37 $_{ID}$	2.47 $_{ID}$	2.27 $_{ID}$	0.80 $_{ID}$	0.73 $_{ID}$
σ^2 (Residual variance)	20.1	18.61	18.83	17.14	4.21	3.75	3.55	3.52
Observations	712	705	619	617	707	705	707	705

[a] Time (0-12 months); [b] Treatment (comparison is reference); [c] Interaction (time*comparison is reference); [d] Gender (women is reference); [e] City of residence (Vancouver is reference); [f] Season (April-July is reference); [g] Age (under 40 is reference)

Table 3.6 Logistic random intercept models on impact of a bicycle skills training course over one year for odds of being confident

	I can ride a bicycle safely on a street with cars		*I can use a map to choose a suitable route for me to cycle*		*I know where safe bike routes are*	
	Base	**Adjusted**	**Base**	**Adjusted**	**Base**	**Adjusted**
Fixed Effects	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Time[a]	**1.12 (1.05 – 1.19)**	**1.12 (1.06 – 1.19)**	**1.14 (1.05 – 1.24)**	**1.17 (1.07 – 1.27)**	**1.07 (1.02 – 1.14)**	**1.08 (1.02 – 1.15)**
Treatment: course[b]	**0.27 (0.09 – 0.79)**	0.32 (0.10 – 1.00)	**0.26 (0.07 – 0.97)**	**0.38 (0.09 – 1.57)**	**0.24 (0.08 – 0.68)**	**0.29 (0.09 – 0.94)**
Time*treatment[c]	0.97 (0.87 – 1.09)	0.96 (0.86 – 1.08)	0.91 (0.80 – 1.04)	0.89 (0.78 – 1.02)	0.99 (0.89 – 1.10)	0.99 (0.88 – 1.10)
Covariates						
Gender: men[d]		**7.08 (2.45 – 20.45)**		**4.85 (1.36 – 17.26)**		2.54 (0.92 – 6.98)
City: outside Vancouver[e]		1.41 (0.62 – 3.21)		1.27 (0.47 – 3.49)		0.74 (0.32 – 1.69)
Season: Aug-Oct[f]		0.8 (0.32 – 2.00)		0.77 (0.24 – 2.45)		1.07 (0.41 – 2.75)
Age: over 40[g]		0.75 (0.32 – 1.80)		2.67 (0.89 – 8.04)		1.73 (0.70 – 4.28)
Random Effects						
T_{00} (Random intercept)	3.29	3.29	3.29	3.29	3.29	3.29
σ^2 (Residual variance)	4.98 ID	4.73 ID	7.28 ID	6.88 ID	4.79 ID	5.04 ID
Observations	705	704	704	703	706	705

[a] Time (0-12 months); [b] Treatment (comparison is reference); [c] Interaction (time*comparison is reference); [d] Gender (women is reference); [e] City of residence (Vancouver is reference); [f] Season (April-July is reference); [g] Age (under 40 is reference)

3.4. Discussion

Given the multiple health benefits, increasing bicycle use is desirable from an individual and societal perspective. This study assessed the impact of a community-based bicycling training skills program related to increases in bicycling frequency and confidence over one year. We compared 135 intervention participants with a comparison population and examined the number of days participants reported using bicycles overall, as well as for commuting, errands, and leisure. We found that participants bicycled more frequently for commuting than for either errands or leisure, but the highest participation rates (i.e., if participants bicycled at all) was for leisure. One year after the course, we did not see lasting increases in bicycling in course participants as compared to the comparison group. We also examined changes in confidence pertaining to bicycling on streets with cars, using maps to find routes, or knowing about safe routes, but found no lasting effect of the program on confidence.

Our findings contrast with a handful of studies on adult bicycle courses that have documented significant increases in bicycling (Bernstein et al., 2017; Johnson and Margolis, 2013) or confidence (Bernstein et al., 2017; Rissel and Watkins, 2014; Telfer et al., 2006; Transport for London, 2016). Potential reasons may be differences in course content or duration, participant demographics, or other contextual factors. It may be that this particular course configuration, a brief 2 - 4.5 hour mixed classroom/on-road design, was not sufficient to have lasting impacts for the average participant. Alternatively, it may be the course did not address critical barriers facing participants. For example, the Behaviour Change Techniques that were used in the bicycle course (Table 3.2) focused on teaching skills and knowledge (addressing capability and motivation of COM-B) but did not target social or physical opportunity. Reviews suggest effective strategies for the initiation and maintenance of physical activity include self-regulation techniques such as goal setting, self-monitoring, action planning, or prompts (Hynynen et al., 2016; Murray et al., 2017), whereas interventions aiming to change transportation behaviour may need to incorporate different techniques to actually disrupt behaviour patterns (Arnott et al., 2014). Thus, it may be that participants who took the course with the intent to bicycle more often need more opportunities to ride bicycles, in supportive or social settings, to put their new skills into practice. Research shows that ongoing support is vital for physical activity maintenance (Murray et al., 2017).

3.4.1. Bicycling by trip purpose

The majority of course participants were already bicycling – about half were bicycling five or more days per month. To better understand bicycling behaviours and identify opportunities for increased active travel, we captured bicycling for different purposes. This is important for several reasons. First, the drivers for using a bicycle differ by trip purpose. Commuters and recreational bicyclists have different characteristics and preferences, and tailored interventions may be needed to facilitate mode shift (Buehler and Pucher, 2012; Heesch et al., 2014). For example, for those who feel bicycling with traffic is a barrier, bicycling for work or shopping may be harder to accomplish than bicycling for leisure. Second, many cities have goals to replace short-distance car trips with active travel modes (City of Vancouver, 2012a; Mitra et al., 2016). Data that distinguishes bicycling for transportation from bicycling for leisure is vital to assess progress toward this goal. Third, commuting is often a strategic target for mode shift because it is a repetitive activity and can be potentially incorporated into daily routines (Heinen et al., 2010), although work trips constitute only ~20% of all travel (Banister et al., 1997).

3.4.1.1 Commuting

If participants commuted by bicycle, it was their most frequent reason for bicycling. As seen elsewhere (LeVine et al., 2014; Winters et al., 2010), this may arise as commuting involves travel to/from fixed locations at fairly consistent schedules, facilitating habitual patterns (Kurz et al., 2015; Stinson and Bhat, 2004). Men bicycled for commuting more often than women, congruent with well-documented gender differences in bicycling in the US, Canada, Australia, New Zealand, and UK (Garrard et al., 2012). Living in the city of Vancouver was also found to be a predictor of bicycle commuting. This could reflect the denser bicycle network found in Vancouver versus than the surrounding municipalities, as bicycle infrastructure is related to commuting (Pucher et al., 2012). Other determinants of bicycle commuting, such as distance, topography, and income (Heinen et al., 2010) were either not measured or were found to have little impact on bicycling usage over time.

3.4.1.2 Errands

Participants tended to bicycle for errands less frequently than for commuting or leisure. While many determinants of bicycling to work and for errands are similar (e.g. density of bicycle network, distance, secure storage), there are also differences. For example, errand trips may have more complicated trip chaining and logistics, thus making planning for errand trips harder (Stinson and Bhat, 2004). Errands were the only trip type without a gender disparity. While in our sample gender was not related to errand bicycling, previous studies have suggested that women are more likely to use bicycles for shopping, errands, or visiting people (LeVine et al., 2014), in line with a trend for women to make more household-related trips.

3.4.1.3 Leisure

At baseline, more participants participated in bicycling for leisure than for any other trip purpose, with two-thirds (68%) reporting bicycling for leisure in the past month. The popularity of bicycling for leisure has been highlighted previously (Goodman and Aldred, 2018; Heesch et al., 2014, 2012; Menai et al., 2015). Potential facilitators of leisure bicycling may be greater flexibility to choose the days, times of day (avoiding busy road times), or routes, as compared to commuting by bicycle (Heesch et al., 2012). Leisure bicycling affords greater flexibility and is “unconstrained by space or time” (Boyer, 2018, p. 409), making it perhaps more possible for more people. Further investigation, perhaps through qualitative research, may reveal how those bicycling for leisure may transition to transport or errand bicycling. We did see short-term increases in bicycling for leisure amongst course participants relative to the comparison, although this was not sustained at the one year follow up.

3.4.2. Intervention impact on confidence

The course was not associated with increases in confidence for bicycling on streets with cars, using maps to find bicycling routes, or knowing the location of safe bicycle routes. That said, confidence started quite high; at baseline at least 50% of participants were already confident. Men were more confident on most measures as is consistent with other studies (Heesch et al., 2012). Also, we observed that confidence increased in both course participants and the comparison group over the one year follow up. It may be that the comparison group, people who had registered for a course but not

taken it, had been motivated to find other ways to support their bicycling training. Confidence to bicycle on streets with cars is important in the Vancouver context, as much of the bicycle network is composed of local street bikeways (shared-roadways). Route finding is also important, as different route types carry different bicycling safety risk (Winters et al., 2013). For this reason the course emphasized using municipal bicycle maps and Google Maps' Cycling Directions to plan routes and locate dedicated bicycle infrastructure—including local street bikeways (often not visible from public transit routes or primary arterial roads). Although we modelled only the three confidence areas targeted by the course, we asked about nine different aspects of bicycling confidence. At baseline, participants were least confident travelling by bicycle with things to carry, in rainy weather, or with children. These are topics practitioners should consider addressing to promote bicycling for utilitarian purposes.

3.4.3. Implications for policy and practice

Bicycle skills training courses have potential to address individual-level barriers such as low confidence, not knowing rules, or insufficient bicycle handling skills (Handy et al., 2014), although cannot directly address systemic barriers such as distance, infrastructure, or weather. On their own, courses may not be potent enough to overcome systemic barriers to bicycling. For this reason, experts suggest that bicycle courses may have greatest potential for increasing ridership when nested within comprehensive packages of integrated and complementary interventions to encourage bicycling (Johnson and Margolis, 2013; Pucher et al., 2010; Rissel and Watkins, 2014). Physical infrastructure, education programs, promotional activities and incentives need to be designed to interact with each other to leverage synergies (Pucher et al., 2010). Additionally, bicycle courses could be combined with social opportunities to engage in bicycling, such as group rides or follow up sessions involving bicycling on streets. Our findings suggest that courses facilitate short-term increases in leisure bicycling. The increase in leisure bicycling was shortly after the intervention, suggesting follow up support for trainees may be helpful to sustain their bicycling. Bicycling for errands was the least frequent trip purpose and did not increase over time. If cities hope to encourage bicycling for both commuting and errand trips, then common barriers need addressing.

This study focused on the outcomes of reported changes in bicycling frequency and confidence, but courses address other important elements that ultimately shape

behaviour, such as shifting personal perceptions and meanings about bicycling (Schneider et al., 2018). Our own interviews with a subset of course participants found that they felt the course had made them more aware as drivers how to share the road with bicyclists, and that formal training had enabled them to model competent bicycling behaviour to children and peers. These shifts may be especially relevant in places such as Vancouver without universal school-based bicycling education. To enhance access, bicycle courses would ideally be free or minimal cost and offered on broader scale including in workplaces and community centres.

In this study, course participants were mainly women though the course was not specifically women-oriented. The gender disparity in adult bicycle courses has been found elsewhere (Rowe et al., 2016; Sersli et al., 2019a). In interviews with women (we did not interview men) we heard that participants enrolled in courses to improve confidence to ride on streets with cars, and to be more aware of rules pertaining to bicycling on shared streets with other users. Societal perceptions and meanings about bicycling may influence course participation. For example, some participants felt that bicycle courses were commonly perceived by others as being for children or those with very low skill. To broaden the appeal of courses and their uptake, courses could be advertised as beneficial for a variety of skill and confidence levels.

3.5. Strengths and limitations

Major strengths of this study are its longitudinal quasi-experimental design which enabled us to assess bicycling trajectories for individuals over time, the high (99%) retention rate, and the incorporation of a comparison group. Comparison groups are often missing from bicycle intervention evaluations (Pucher et al., 2010), and to our knowledge this is only the second study of adult bicycle skills training with a comparison group. Our comparison group consisted of people who enrolled in but did not attend a course. We selected this group intentionally to use a comparison group that was interested in bicycling. In the absence of attending the course, comparison participants may have found other avenues to support bicycling behaviours, which may have attenuated differences in changes in bicycling and confidence observed in the two groups. Our comparison group was smaller than the intervention group, a function of the recruitment method. A greater sample size overall would be possible with additional years of data collection, beyond the two seasons used here. The comparison group

could expand if eligibility criteria were relaxed, or if randomization to course timing were possible. There may have been social desirability bias in the reporting of bicycling behavior in the online surveys, however, any bias would be non-differential across course and comparison groups. To note, people were enrolled continuously: people who took courses later in the summer were more subject to seasonal effects in follow up (especially at 3 months), and the comparison group had a greater proportion of late enrollers. We aimed to address this by controlling for seasonality. Finally, it is likely there were some overlap between the different “types” of bicycling, especially when trip purposes where combined. Future work may aim use more nuanced survey questions, or employ qualitative methods to more specifically understand trip chaining, complex trip characteristics, and how participation in training courses may shape people’s overall bicycling trajectories.

3.6. Conclusions

Our research adds to the few studies assessing the impact of bicycle skills training on bicycle uptake in adults. We did not find increases in overall bicycling or for commuting or errands, nor was the course associated with increases in confidence, relative to a comparison group. We found modest increases at one month follow up in leisure bicycling among those who completed a course, although increased bicycling was not sustained over one year. We encourage future studies to include multiple follow up time points to study maintenance in behaviour change, and to include bicycling for different trip purposes. Bicycle infrastructure is a necessary prerequisite to increase bicycling. Bicycle courses are a part of an overall strategy to increase bicycling, but they cannot substitute for a safe and attractive bicycling environment.

Chapter 4.

Easy as riding a bike? Bicycling competence as (re)learning to negotiate space

Abstract

Safety concerns, notably sharing road space with motor traffic, pose barriers for bicycling. To address safety concerns, bicycle courses are designed to provide skills and know-how for bicyclists to share road space with traffic. This paper used Social Practice Theory combined with a critical gender lens to examine the impact of a bicycle course for women living in Vancouver, Canada. We aimed to: 1) describe bicycling competences and associated materials and meanings; 2) compare bicycling competences at different stages of uptake and maintenance; and 3) identify gendering processes shaping bicycling practices. We conducted interviews with 32 women in the year following their participation in a bicycle course. Data collection and analysis were guided by interpretive description methodology. Participants described competences as skills for road positioning and route-finding, knowing formal (laws) and informal rules (etiquette) to interact with other road users, and having strategies to minimize gender harassment. Regarding uptake and maintenance, women with opportunities to engage in bicycling cultivated competences more quickly. Those without suitable bicycles rarely rode; others described a virtuous circle where more time in the saddle led to greater confidence. Gendering processes shaped nearly all aspects of bicycling and included safekeeping (taking disproportionate personal responsibility for safety) and cultivating an assertive bodily comportment to take up space. We recommend that courses be augmented with support to acquire suitable bicycles, social opportunities for bicycling, continued investment in bicycle infrastructure, education for motorists, and discussion regarding etiquette between bicyclists.

4.1. Introduction

Cities are promoting urban bicycling. Over the past two decades, substantial research has focused on how to increase rates of bicycling. A barrier for many people is fear related to sharing road space with motorized traffic (Heinen et al., 2010; Pucher et

al., 2010). Despite ample evidence showing that separated infrastructure and traffic-calming are conducive to bicycling (Aldred et al., 2016; Nello-Deakin, 2020), chronic underfunding has limited the scale of necessary infrastructural change (Aldred et al., 2019). Given that many cities are still in the process of creating dense, connected, and high quality bicycle infrastructure, urban bicycling demands a certain level of skill and confidence to share streets with cars.

Bicycle skills training courses ('courses') are promoted as a cost-effective way to increase bicyclists' confidence, perceived safety, and awareness of traffic rules (Nachman and Rodríguez, 2019; Sherriff, 2014). Infrastructure changes to streets and courses can interact synergistically as multi-layered intervention strategies, with the former improving safety conditions and the latter increasing skills and knowledge (Pucher et al., 2010). Further, programming interventions, such as courses, are more easily customized to meet the needs of specific groups (Kandt et al., 2015; Papagiannakis and Vitopoulou, 2015). Recent scholarship recommends conceptualizing current and prospective bicyclists as heterogenous groups with different needs (Damant-Sirois et al., 2014), and courses may be helpful to target underrepresented populations.

Currently, there is interest in equity in bicycling (Lugo, 2018). A persistent gender gap in bicycling is found in countries with low bicycling levels, with men approximately three times as likely as women to use bicycles (Buehler et al., 2020). Numerous studies have attributed this discrepancy to differences in men's and women's risk perceptions and trip characteristics, but few have examined gendered processes underpinning such outcomes (Ravensbergen et al., 2019). Gender is relational, historically situated, interwoven with other social practices, and is reproduced through social institutions and social relations of power (Connell and Pearse, 2014). In line with recent movement towards more critical and powerful accounts of gender and bicycling, this paper argues bicycling is not simply shaped by gender but also acts as a site for the production of gender (Heim LaFrombois, 2019; Lam, 2020; Ravensbergen et al., 2019). To this end, we use the term gendering to denote the "ongoing and always incomplete processes" that constitute categories of man/masculine or woman/feminine (Bonham et al., 2015, p. 180).

To better account for the broader social processes that shape people's urban movement, a growing number of researchers are turning to Social Practice Theory

(Caldwell and Boyer, 2018; Guell et al., 2012; Nettleton and Green, 2014; Smeds, 2019; Spotswood et al., 2015). Together with gender theory, Social Practice Theory provides a lens to examine how women's urban bicycling—including but not limited to gendered meanings and performances—shifts with the introduction of a policy, technology, or in this study, intervention (Mechlenborg and Gram-Hanssen, 2020). This paper presents findings from research conducted in Vancouver, Canada on the impact of a bicycling course. Participation in this course reflected a pattern observed elsewhere in the literature: that women tend to disproportionately participate in (entry level) bicycling courses, even when courses are not specifically targeted to women (Nachman and Rodríguez, 2019; Rowe et al., 2016; Sersli et al., 2019a). Vancouver is an urban environment that has been extending its bicycle infrastructure and also supports initiatives, including adult bicycle skill training courses, to encourage more active travel. This paper has three aims: first, to describe bicycling competences and associated materials and meanings; second, to compare those bicycling competences at different stages of uptake and maintenance; and third, to identify gendering processes that shape bicycling practice.

4.2. Literature review

To understand the links between bicycling, gender, and interventions, two areas of literature are reviewed. We first focus on bicycling research and gender, focusing attention on the ways gender has been portrayed. We then introduce Social Practice Theory as a theoretical lens for analyzing bicycling interventions designed to encourage bicycling.

4.2.1. Bicycling research and gender

Gender differences in bicycling are well-documented, with three primary overlapping explanations: safety concerns regarding traffic and personal safety pertaining to public space; men's and women's different trip characteristics and division of household labour; and cultural norms and meanings associated with bicycling that are framed as masculine or feminine (Aldred et al., 2017; Xie and Spinney, 2018). The sociocultural processes accounting for these visible binary differences are not sufficiently

well understood, underscoring the need for an interdisciplinary critical gender lens to account for the complexities and paradoxes of power (Carey et al., 2018).

4.2.1.1 Traffic safety concerns

Traffic safety concerns pose the primary barrier to urban bicycling for most people in low-bicycling contexts (Aldred et al., 2017; Heesch et al., 2012). Women are less inclined than men to ride on streets without bicycle-specific infrastructure or separation from traffic (Aldred et al., 2016; Teschke et al., 2017). There has been a tendency in the transport literature to account for these patterns as natural differences (i.e., women are more risk averse) (Bonham et al., 2015), but research going forward is encouraged to probe underlying gendering processes (Ravensbergen et al., 2019). For example, alternative explanations suggest that risk tolerance is positively associated with social status, and that it is also influenced by gendered expectations based on gender stereotypes (Barrie et al., 2019; Fisk et al., 2017).

4.2.1.2 Personal safety concerns

Personal safety concerns, specifically sexual harassment from men, is known to shape women's mobility in cities (Law, 1999; Loukaitou-Sideris, 2016) and may also underpin their bicycling. Women are deterred from environments that reduce feelings of personal safety (such as poorly lit or isolated locations) (Xie and Spinney, 2018). For example, US studies have found that street harassment were significant concerns for women bicyclists and contributed to their fear, anxiety, and stress (Heim LaFrombois, 2019; Lubitow et al., 2019).

Women have been oriented toward safety, fear, and vulnerability differently than men. Starting in girlhood women are taught to protect themselves by safekeeping in public spaces: for example, dressing conservatively, not making eye contact, avoiding dark or isolated places, being alert and aware, avoiding going out at night alone, having precautionary strategies in place if one must go out alone at night, and so on (Stanko, 1997; Starkweather, 2007; van Eijk, 2017). Safekeeping can be considered a form of disciplinary power and of doing gender. Safekeeping illustrates Hanson's (2010) argument that mobility and gender are co-constitutive.

4.2.1.3 Trip characteristics

Women's responsibility for childcare and household labour is thought to contribute to the bicycling gender gap. Across European countries, those with greater gender equality tended to have a greater percentage of women bicycling (Prati, 2018). The trend was especially pronounced when examining gender gaps in time spent on caring, cooking, and housework. Studies indicate that transporting children and grocery shopping is more difficult to accomplish by bicycle than car (Bonham and Wilson, 2012a; Dickinson et al., 2003; Singleton and Goddard, 2016), although these barriers could potentially be overcome with equipment (Riggs and Schwartz, 2018) or policies to enable these trips to be made faster and more conveniently by bicycle than by car (Garrard et al., 2012; Ravensbergen et al., 2020).

4.2.1.4 Cultural norms and meanings pertaining to the bicycle

Bicycling has long been associated with masculinity, although periodically tempered by feminisation demonstrating that the relationship of gender and bicycling is context-specific (Mackintosh and Norcliffe, 2007; Oosterhuis, 2016). In low-bicycling contexts it is associated with sport or high risk tolerance (Aldred, 2013; Daley and Rissel, 2011). Sport bicycling is synonymous with speed and competition (Fullagar and Pavlidis, 2012; Prati et al., 2019)—what Barrie et al. (2019, p. 116) call "cycling masculinities". Furthermore, for decades the dominance of the vehicular bicycling paradigm encouraged speed, efficiency, and assertively claiming the road (McCullough et al., 2019). Together, sport and vehicular bicycling cultures have fostered an image of urban bicycling where speed, performance, skill, and assertiveness are valorized (Osborne and Grant-Smith, 2017). This image is unappealing and alienating for many people (Aldred et al., 2017; Bonham and Wilson, 2012a; Lam, 2017).

Studies have suggested that practices central to bicycling on roads with other vehicles, such as assertively taking up space, contradicts the ways women are socialized to occupy public space (Heim LaFrombois, 2019; Lam, 2020). In developing a theory of gendered bodily comportment, Young (2005) argues that girls are discouraged from using their bodies freely and fully, and are not taught to take up, use, or move through space with confidence. Acquiring this assertiveness is a learned skill (Bonham and Wilson, 2012a; Steinbach et al., 2011). The next section examines learned skill and bicycling within Social Practice Theory.

4.2.2. Applying Social Practice Theory to bicycling

Social Practice Theory moves toward a greater emphasis on social context and conventions and away from individual attributes. This analytic lens enables us to understand broader societal patterns as well as variation at the individual level (Halkier and Jensen, 2011; Mylan and Southerton, 2017). Shove and colleagues (2012) have integrated present Social Practice Theory as a streamlined model, where practices are comprised of three interdependent elements: competences (skills, know-how); materials (physical resources); and meanings (values, sociocultural significance, embodied understandings of the situation). For example, the practice of bicycle commuting might include competences of fitness and navigation; materials of a bicycle and infrastructure; and meanings of bicycle commuting as a healthy activity (Larsen, 2016; Spotswood et al., 2015). Furthermore, individual practices are woven together ('bundled') with other aspects of daily life, and practices bundle tightly, loosely, or not at all (Shove et al., 2012). For example, the practice of bicycle commuting may or may not bundle with the practice of taking children to daycare (Sersli et al., 2020).

Recruiting people to bicycling necessitates thinking about the three elements and ideally interventions to promote bicycling would address all three (Spurling and McMeekin, 2015). Yet bicycle skills training courses address only some practice elements: primarily competence (e.g., rules of the road, skills such as signaling, shoulder checks, and road positioning), and to a much lesser extent, materials (e.g., learning about bicycle routes), and meanings (e.g., seeing people like themselves in the course, thus normalizing bicycling).

The first element—competence—can be more fully conceptualized if broken into the sub-elements of skills and rules (Huber, 2017). Skills refer to "embodied, mostly tacit competences, which are acquired through repeated performances" (Huber, 2017, p. 58). Rules refer to explicit guides of how things should be done. The practice of urban bicycling is governed by formal rules (i.e., laws) as well as social norms developed by its community of practitioners (informal rules, or etiquette).

From past studies on bicycling incorporating Social Practice Theory, we have learned competences are context-dependent. In low-bicycling places, people need to work harder to attain competences and high competence is demanded where bicycle

infrastructure is less available (Aldred and Jungnickel, 2014; Green et al., 2012). In high-bicycling places, busy bicycle infrastructure requires competence to ride in close proximity to faster, slower, less skilled, or reckless others (Larsen, 2016). Learning and observing etiquette—norms and expectations—is perhaps the trickiest competence to acquire, as these are often unwritten (Larsen, 2018; Latham and Wood, 2015).

4.3. Methods

4.3.1. Study setting

Vancouver's bicycling rates are high for a North American city, and bicycle journey-to-work mode share has nearly doubled from 3.3% in 1996 to 6.1% in 2016 (Statistics Canada, 2016, 1996). The city has invested in improving and extending its bicycle route network. Much of the bicycle network is local street bikeways (shared roadways along local streets, typically traffic-calmed), complemented by protected bike lanes (physically separated from motor vehicles), painted bike lanes (portion of roadway designated for bicyclists), and shared use lanes (painted markings on busy streets) (City of Vancouver, 2019). The city has also identified women, children, older adults, and people new to Canada as important target populations for bicycling promotion (City of Vancouver, 2012b).

4.3.2. Study design

This qualitative study is part of a mixed-methods investigation of the impact of urban bicycle skills courses delivered in Metro Vancouver. The quantitative approach assessed changes in bicycling frequency and confidence over one year for a cohort of course participants, with interviews examining processes associated with starting and maintaining bicycling. In brief, courses aimed to increase comfort levels for riding in various urban environments, including on streets shared with cars, through teaching traffic safety knowledge and bicycle handling skills.

In the study, we recruited interview participants who completed bicycle courses in 2016 and 2017 (Sersli et al., 2019b) from a sample of main study cohort questionnaires who were willing to be contacted for interviews. From this pool we recruited a diverse sample of women (over 19 years of age) in terms of bicycling uptake, years in Canada,

family status, and neighbourhood. Given cities' desires to address the gender imbalance in bicycling, and that two-thirds of bicycle course participants were women, we restricted interviews to women. We contacted 60 women by email and 32 consented to interviews. The lead researcher (SS) conducted semi-structured interviews in 2018 (12-26 months after women completed courses, median follow up 20 months). Interviews (45-120 minutes, median length 75 minutes) were conducted in English, either at the research unit, participants' homes, workplaces, park, library, or by phone, according to participants' preferences. Recordings were transcribed verbatim by a transcriptionist, and double-checked for accuracy by SS. All participants were given pseudonyms for analysis and reporting.

We began each interview with the question: "Tell me about bicycling in your life, starting with when you first started riding a bike" and continued with questions pertaining to different trip types (commuting, errands, leisure), where and with whom participants bicycled, and the impact of the bicycle course. We probed for conditions that inhibited and enabled bicycling. Participants were aware that the purpose of the interviews was to ask about women's bicycling experiences. In the latter part of the interview, if gender had not been yet raised, we asked participants how they thought gender informed their bicycling practices.

4.3.3. Data analysis

We followed an interpretive description methodology (Thorne, 2008) where we concurrently collected and analyzed data, constantly compared data within and across participants, and wrote memos throughout data analysis to identify gaps, record decisions, and document conceptual insights. We applied an iterative two-cycle coding approach (Saldaña, 2015). In this approach, first cycle coding aids with initial organization and sorting, and second cycle coding develops thematic concepts by reorganizing and condensing data from the first cycle. First cycle codes were both inductive and deductive, the latter directed by Social Practice Theory as a conceptual framework. During second cycle coding, we used matrices to identify patterns, commonalities and differences to generate initial themes (Bazeley, 2009).

To compare bicycling competences at different stages of uptake and maintenance, participants were classified as belonging to one of four trajectory groups

based on bicycling before and after the course. A participant's trajectory was assessed by reviewing her bicycling participation at five time points: the first four captured by her questionnaire responses, and the fifth during the interview. Those who reported bicycling at least once per week for any trip purpose across the five time points were classified as *consistent weekly* bicyclists; those who steadily increased bicycling since the course were *steady increasers*; those with substantial increases and decreases since the course were *fluctuators*; and those who bicycled only a few times or not at all since the course were *rare*. We used NVivo 12 for data analysis. The Simon Fraser University Research Ethics Board granted ethics approval for this study (2017s0653).

4.4. Results

4.4.1. Sample characteristics and trajectory groups

Participants were diverse in sociodemographic composition and bicycling experience. They were 20 to 60 years in age and had diverse immigration and ethnic backgrounds (Table 4.1). The majority lived with male partners, in the city of Vancouver, and in bikeable neighbourhoods. There were both experienced and inexperienced riders in the sample (Table 4.2). Approximately half had less than 2 years of experience bicycling as an adult, including four who had not ridden since childhood and two who learned to bicycle shortly before the course. Participants bicycled for a variety of trip purposes, with nearly two-thirds riding predominantly for transportation (Table 4.2).

Table 4.1 Sociodemographic characteristics, overall and stratified by bicycling trajectory

	All participants (N=32)		*Consistent weekly (n=11)*	*Steady increaser (n=10)*	*Fluctuating (n=5)*	*Rare (n=6)*
Characteristics	**N**	**%**	**n**	**n**	**n**	**n**
Age (years)						
20-29	4	13%	2	0	2	0
30-39	14	44%	4	5	2	3
40-49	9	28%	2	4	1	2
50-59	5	16%	3	1	0	1
Household structure						
Living alone or with housemates	10	31%	5	1	4	0
Single with children	3	9%	0	0	0	3
Couple, no children	6	19%	2	3	0	1
Couple, with children	13	41%	4	6	1	2
Settlement status						
In Canada < 5 years	8	25%	2	5	1	1
In Canada > 5 years	5	16%	1	2	1	0
Born in Canada	19	59%	8	3	3	5
Ethnicity *						
Asian	12	38%	4	6	2	0
Latina	2	6%	1	1	0	0
Mixed	4	13%	1	1	1	1
South or West Asian	4	13%	1	1	0	2
White	10	31%	4	1	2	3
City of residence						
Burnaby/New Westminster	7	22%	1	3	1	2
North Vancouver	2	6%	1	1	0	0
Richmond	1	3%	0	1	0	0

Characteristics	All participants (N=32)		*Consistent weekly (n=11)*	*Steady increaser (n=10)*	*Fluctuating (n=5)*	*Rare (n=6)*
	N	**%**	**n**	**n**	**n**	**n**
Vancouver	22	69%	9	5	4	4
Bike Score at home residence**						
85-100	25	78%	9	6	5	5
70-84	3	9%	0	3	0	0
40-69	4	13%	2	1	0	1

*Ethnicity was self-described. 'Asian' includes Chinese, Filipina, Japanese, and Southeast Asian identities.

**Bike Score is a composite measure based on density of bicycle lanes, hilliness, destinations, and road connectivity (Winters et al. 2016)

Table 4.2 Adult bicycle experience and main trip type, overall and stratified by bicycling trajectory

	All participants (N=32)	*Consistent weekly (n=11)*	*Steady increaser (n=10)*	*Fluctuating (n=5)*	*Rare (n=6)*
Bicycle experience	**N**	**n**	**n**	**n**	**n**
Years bicycling as an adult*					
0 - <2	15	4	4	3	4
2 - <5	8	2	2	2	2
5+	9	5	4	0	0
Main trip purpose					
Mostly transportation	9	6	0	1	2
Mostly leisure	5	0	4	0	2
Mostly escort (transporting or accompanying children)	4	0	2	1	1
Mix**	12	5	4	3	0
No trips taken since course	1	0	0	0	1

*Years bicycling as adult at time of course

**Mix is equal weight of two or more trip types

Two-thirds of participants were *consistent weekly* or *steady increaser* bicyclists. There were no clear sociodemographic differences between the four groups (Table 4.1). *Consistent weekly* bicyclists rode mainly for transportation or a mix of trips (Table 4.2). *Steady increasers* tended to ride infrequently or not at all at the time of the course. Some steady increasers rode bicycles predominantly for leisure, but others reported starting to make more transportation trips after the course. *Fluctuators* had no clear trajectories in their bicycling patterns over the study period. Half of *rare* participants, until the time of the course, had not bicycled since childhood.

Applying a Social Practice Theory-informed framework to examine the element of competence (skills and rules), we identified four themes in women's descriptions related to bicycling competence: 1) skills as continually learned; 2) knowing rules and their limitations; 3) unlearning being in the way of faster traffic; and 4) negotiating street harassment. We identify places where competence differed by bicycling trajectory group, but generally we found differences between the rare bicyclists and others (consistent weekly bicyclists, steady increasers, and fluctuators more similar), highlighting the differential role that competence plays in initiating and maintaining bicycling.

4.4.2. Theme 1: Easy as riding a bike? Skills as continually learned

Participants contested the notion that bicycling was natural and intuitive. Basic handling skills were an essential prerequisite for urban bicycling, yet basic skills required repeated practice, time, and safe places.

4.4.2.1 Beyond balancing and braking

Like others returning to bicycling in adulthood (Rowe et al., 2016), Alice realized the skills she had developed as a child were insufficient to ride on Vancouver streets: "When I learned to ride a bike, you know, when I was eight years old, it was, like, just leisurely going in a circle. I didn't really have to worry about hills or shifting gears". Not all participants had people in their lives who could demonstrate techniques such as shifting gears or how to lock a bicycle securely, and thus looked to courses for learning opportunities.

For most participants, the course represented the first time receiving any formal instruction, yet some—especially those who had learned to ride as children in Canada—

felt embarrassed. Tara explained her embarrassment stemmed from a taken for granted assumption “you’re doing something that lots of children can do, so why do you need to [take a course] as an adult?” This reflects a widespread perception that bicycling should be easily accomplished with little skill or training, unlike other activities where practice, drills, and learning progression are seen as essential pathways toward improvement. Whereas immigrant women were not embarrassed about low handling skills, pointing out they had little opportunity to learn or practice in their countries of origin, their Canadian-raised counterparts worried they would be teased or mocked by peers. They were keenly aware of their visibility where bicycle skills and fitness would be on public display, as reported elsewhere (Heim LaFrombois, 2019; Horton, 2007; Steinbach et al., 2011).

4.4.2.2 Time in the saddle

Participants reported a virtuous circle between confidence and bicycling, where the more time they spent riding the more comfortable they became, similar to other studies (Biggar and Ardoin, 2017; Janke and Handy, 2019). Some credited the course with giving them an initial boost of confidence to start riding on new types of infrastructure, thus broadening the areas where they were able to go and sparking new opportunities. Prior to the course some of the newer riders, like Victoria, had only bicycled in the park but afterward started using local street bikeways. Local street bikeways enabled them to use bikes more often and for a wider variety of trips.

Time in the saddle served to not only develop handling skills, but also expanded the boundaries of what felt normal. Jane, who returned to bicycling shortly before the course, transitioned to a more confident rider over 15 months as she acquired more “time in the saddle”. She explained:

> in the beginning everything was scary. And I felt like I was going to fall all the time. And most recently I think I had a full load of groceries on the bike and I had to stop really suddenly and I kind of fishtailed a little bit. And that [felt okay], I think I had along the way gotten stronger and gained a bit more experience.

Jane’s description illustrates why social practice theorists argue “practices evolve with bodies” as “bodies are affected and changed by experiences” (Wallenborn and Wilhite, 2014, p. 59). Understanding the relationship between embodiment and practice could lead to new course design, where skill development and opportunities for repeated engagement with bicycling are emphasized.

Although all participants were aware that comfortable bicycling would be achieved by practice, acquiring time in the saddle was easier for some versus others. The *consistent weekly* and *steady increaser* bicyclists were more likely to have others to bicycle with, to live close to protected bicycle infrastructure, or to have had previous bicycling experience. Those who bicycled *rarely* had few opportunities to ride because they didn't have adequately fitting bicycles (five of six participants in this group), compounded by self-described low handling skills.

Some participants suggested they needed more intensive programming to address low handling skills, involving additional sessions and social supports to practice skill development. Andi, still uncomfortable on her bicycle after the course, defined this form of support as "hand-holding":

> that's kind of like what I needed with the bicycling. I needed the course and then I also need somebody [to] take me to the bike store and teach me what I'm looking for on a bicycle … and then how to fit it ... I just wish [for someone] who could hold my hand.

After the course, a few participants sought social opportunities for additional bicycling through social rides (informal group rides open to the public) but had not found one suitable for their bicycling ability.

4.4.3. Theme 2: Knowing rules and their limitations

Related to competences, every participant made reference to "rules". These included formal rules and responsibilities (e.g., as specified in the Motor Vehicle Act) for bicyclists to use roads. Competence included knowing what to do and having the handling skills to observe formal rules such as using hand signals, yielding, and where to position oneself on the road.

4.4.3.1 Managing safety, fitting in

The course earmarked dedicated time to discuss traffic rules. The majority of participants wanted to know and follow traffic rules, but the rules for bicyclists were not always clear. Some participants came from countries where it was uncommon for bicycles to share road space with cars, or illegal for vehicles to turn right on a red light. Newcomers, but also those raised in Canada, were also unsure as to how traffic rules applied to bicycling, perhaps reflecting the marginal status and decades-long policy

neglect of urban bicycling. Despite having a driving license and bicycle commuting for many years, Beth said she had never known the “true” or “exact” rules of the road regarding bicycling, suggesting that in practice, rules are not as obvious as simply following the Motor Vehicle Act.

Most regarded knowing traffic rules as an investment in bicycle safety. This desire for knowledge may reflect an extension of safekeeping, where women must continuously manage their own safety. Participants recalled situations where drivers seemed reluctant to exercise right of way near bicyclists. In these situations, being certain of rules helped participants apply better judgement in responding. Sam explained:

> [I’m] not sitting there thinking, oh, is it my turn to go? I’m not second guessing these things. … knowing that rule helps me to know what I’m supposed to do next … the car’s waiting for me to make a move and [decisive action] just creates a much safer situation for everybody.

Furthermore, knowing and following rules was important to be seen as a legitimate road user—not only in the sense of challenging bicycling stigma (Aldred, 2013; Skinner and Rosen, 2007)—but as a protective act from aggression. Eva recalled a driver yelling at her: “‘learn the rules of the road’. And I felt like I *had* followed the rules of the road. But I felt very vulnerable at that moment ‘cause I felt like my skills and my abilities were being questioned.” In a car-dominated environment where Eva’s bicycle skill was on public display, her vulnerability was magnified. Likewise, Tara was conscious of not looking “super skilled or [having] expertise” being also young, brown, and femme, and modified her bicycling to ride “more conservatively” to avoid confrontation.

Knowing and abiding rules was laden with additional meanings of fitting in and being considerate. Yet knowing the rules could be restrictive. Participants newer to Canada learned bicycling on the sidewalk was illegal, which constrained their bicycling options if they were not yet confident to bicycle on the road. For example, although Sharon knew bicycling on the sidewalk was illegal, she felt it was sometimes preferable to riding with traffic: “I feel safer there. Yeah, I know it’s not right.” Participants disliked feeling forced to ride the sidewalk, and those sensitive to transgressing social norms (for example, receiving angry comments from pedestrians) or who had been targeted for enforcement avoided certain routes or chose to walk instead.

4.4.3.2 Rules as insufficient to stay safe

Some participants feared they were invisible to motorists. Despite learning bicyclists have the right to take space on the road, they were concerned about drivers not seeing them. Lucia explained: “even though you know that you are doing it correctly, sometimes [your safety] will depend on other drivers that are not that cautious”. To mitigate risk these participants used avoidance tactics, bicycling only on protected bike lanes and other motor vehicle-free spaces. This consequently shaped the types of trips they were able to take, and illustrates how competence is affected by materials (routes) as well as interactions with other road users (drivers).

Being able to anticipate the actions of motorists was as important as knowing formal road rules, and this competence was learned through both instruction and time in the saddle. Participants employed a variety of strategies to negotiate inattentive drivers. Julia described her riding style as “uber aware” and recounted an incident where she anticipated a motorist would fail to stop:

> [after the course] I went out on the road and literally there was a car at the stop sign. But I slowed down at the intersection ‘cause I knew. I saw the car. And they didn’t even stop. They blew the stop sign.

Other strategies included establishing eye contact, leaving space between themselves and parked cars to avoid dooring, leaving passing space between themselves and moving vehicles, and lowering bicycling speeds. Generally, participants were keen to avoid stressful situations, choosing low-stress routes and maneuvers. This vigilance can be seen as another form of safekeeping.

Safekeeping extended to interactions with pedestrians and bicyclists. To accommodate unpredictable moves, participants developed a style of cautious riding. Maggie explained her daily commute on a busy bicycle route entailed extra care because

> a lot of cyclists don’t know the rules. So I know certain streets, people will come speeding down even though they don’t have the right of way, like, if I’m there first. But if they’re coming fast and can’t stop, I’m going to get hurt.

4.4.4. Theme 3: Unlearning being in the way of faster traffic

Competence involved becoming aware of shared understandings about what is acceptable and appropriate (i.e., formal rules, etiquette) as well as cultivating bodily and mental/emotional capacities to meet these standards. This section examines competence for taking the lane and etiquette for sharing space with other bicyclists. We use the term "unlearning" to emphasize participants' deliberate mental action to supplant dominant meanings of efficiency and the acceptability of holding up faster cars or bicyclists. Feeling entitled to take up space was earned and precarious.

4.4.4.1 Taking the lane and learning to take up space with motorists

The course involved hands-on training to apply the classroom learning and practice road positioning. An epiphany for many came from "taking the lane"—riding far from the curb to take up space in the middle of the lane (Hatfield et al., 2018). In addition to learning they had a right to take up space on the road as legitimate road users, participants were surprised and heartened to learn that taking up space was a safety strategy. Pat remarked

> [in the course] they said visibility's a big thing. Just think visibility. And if you're going to stop at a stop sign, you know, don't go over to the side of the road but sort of position yourself in the center so they see you. And so I do that and I find that cars notice you and they give you space.

Acquiring this assertiveness was a learned accomplishment (Lam, 2020; Steinbach et al., 2011), solidified by repeated practice.

Taking the lane meant that participants had to get over feeling that bicyclists were in the way of traffic. Lianne was initially anxious about being in the way of motorists: "I remember for the longest time I was, like, afraid to ride up that hill … 'cause I never felt fast enough or I would slow down traffic. Now I'm not too concerned about slowing down traffic." Even though participants knew they legally had a right to take up space on the road, feeling entitled to actually take that space was nuanced and context-dependent. In the time since the course, Lianne had joined a road bicycling group and was training for amateur races. As a result she was fast, schooled in bicycle etiquette, and had accrued significant time in the saddle. Her training regime reconfigured her initial bicycling bodily comportment (Young, 2005) and she now saw herself as skilled and capable of occupying road space. By contrast, other participants did not want to

anger impatient motorists. Bicycling on shared streets meant that participants had to be willing to assertively negotiate traffic and tolerate aggression, and some were not always up for the task. Primary strategies to minimize interaction with traffic were seeking routes on quiet streets, at quieter times, or traffic-free spaces.

4.4.4.2 Too slow and in the way: norms of speed amongst bicyclists

Parallel to feeling in the way of motor traffic, participants described the verbal and visual cues from other bicyclists indicating they were in the way. These interactions tended to occur in places with heavy bicycle use. To bicycle in busy places, participants used strategies of avoidance, vigilance, adopting a 'let it go' attitude, or in rare cases, confronting aggressors. Faye described her commute, entirely on protected infrastructure: "When I'm waiting for a red light [where] the bikeways are a bit more narrow—people line up one after the other. I do notice if they pick out that you're slow they kind of jump ahead of you." Some participants attributed this to a form of competitive masculinity, regarded as annoying but inconsequential. Other actions such as yelling and close passes were perceived as assertions of spatial dominance and aggression, and some felt unwelcome in this social environment. After a too-close pass from another bicyclist on a busy bicycle route resulting in fall and injury, Pat changed her commuting schedule to avoid rush hour. She justified this decision: "I'm just cautious. But I don't like to be. I don't think I should. It causes stress that way. I'd rather just enjoy my bike ride to work and, you know, relax and enjoy my bike ride back." She noted that being stressed from other bicyclists was "one of the things that I don't like about biking."

Participants resented feeling in the way or pressured to perform bicycling faster or stronger. Tracy explained: "I find other cyclists very intimidating. They're just—they're in a race and I'm not in a race and it's just all—ugh." She described interactions with other bicyclists on a protected yet narrow and busy route as "cyclists getting upset with me because I'm not doing it right or I'm in their way or something." She disliked feeling she was "going too slow or in their way when they're in such a hurry" and that "[she] should just not even be on [her] bike". She didn't have the option of adjusting her schedule so she opted to not continue bicycle commuting. Tracy's narrative suggests that being unaware or unable to perform the correct etiquette undermined her already tenuous claim to take up space.

4.4.5. Theme 4: Negotiating street harassment and assault

Nearly half of participants brought up personal safety as something that shaped where and when they bicycled. Approximately one-third of the participants used bicycles at night, and personal safety added to traffic safety concerns and posed navigational dilemmas. Participants relied on a lifetime accumulation of safekeeping practices. For example, they bicycled with friends when possible. They sought traffic-lite routes but avoided places that were *too* quiet. Ideal routes had other people around, and routes through parks at night were dismissed. Sandra reflected that her aversion to bicycling through dark and isolated urban spaces was deeply embodied: “it’s so engrained I don’t think about it very much. You try to stay in fairly lit places or trafficky places.”

This would on surface appear not very different from other forms of active travel such as walking or public transit; however, bicycling enabled some participants to feel safer at night than they would otherwise because they could escape more quickly. Travelling home from her evening shifts, Victoria explained:

> it’s actually safer for me to be biking home … I’ve had people stop me or make me uncomfortable when I was on foot. But on the bike I just felt safer … because then I wouldn’t have to talk to anyone. I could just go home quicker and faster.

On a bicycle, harassment could be lessened (by enabling escape), or magnified, especially for younger women. Tara, a racialized person in her 20s, suggested that daytime harassment she experienced was intensified when bicycling: “I feel aware of it in my day-to-day life, and so I feel aware of it when I’m biking.” Alex, also a racialized person in her 20s, explained that compared to the protective space of being in a car, bicycling made her “more accessible to the world” and more visible to the male gaze. Consequently, participants negotiated a visibility paradox where they strived to simultaneously be visible to drivers (traffic safety) and yet also invisible, so as to avoid harassment. Some employed safekeeping practices, such as selecting and adjusting their clothing to be less revealing while bicycling. Yet some participants felt they had few options to make themselves less visible due to age, skin colour, and body size—characteristics that can impact types of harassment (Lubitow et al., 2019; Vera-Gray and Kelly, 2020). Conversely, two participants in their 30s stated they experienced *less* street harassment in Vancouver than other places they had lived; they felt reduced harassment encouraged their enjoyment of bicycling. Generally, participants viewed personal safety

in public space as an extension of larger sociocultural dynamics, rather than specific to bicycling.

4.5. Discussion

This paper examined bicycling competence as recounted by women at different phases of bicycling uptake and maintenance in the year after participating in a bicycle course. In short, competence included embodied skill to use bicycles as well as knowing formal (laws) and informal rules (etiquette) to interact with other road users. Participants felt most confident during the periods they were bicycling regularly, strengthening evidence that confidence and bicycle use is bidirectional (Kroesen et al., 2017), but had different experiences and barriers to acquiring competence. Notably, those who bicycled rarely did not have suitable bicycles, and thus had few opportunities to develop urban bicycling know-how and skills.

4.5.1. Describing competences

In our analyses, competences (skill, knowing formal and informal rules) arose across four themes. The first theme showed that urban bicycling skills were continually learned to adapt to material conditions (e.g., hills, types of infrastructure) and developed through time in the saddle. For most participants, the primary difficulty prior to the course was not the basic mechanics of how to ride a bicycle; rather, they did not have competences needed in urban environments such as road positioning, route-finding, and new forms of social interaction with drivers. The latter underscores that urban bicycling skill is more than a simple individual attribute, but is relational and involves other people (Bissell, 2018; van Duppen and Spierings, 2013). These findings contribute to theoretical positions arguing that social interaction forms an important conduit through which practices are encouraged or discouraged (Hargreaves, 2016; Jacobsen and Hansen, 2019).

The second theme, knowing rules and their limitations, illustrated that participants wanted to know and follow rules but needed to develop additional defensive competences to accommodate other road users. Motorists posed the greatest threat to participants' sense of traffic safety, as found in other studies (Poulos et al., 2019). There are parallels between defensive competences and safekeeping in how participants

assumed disproportionate personal responsibility for safety to compensate for larger structural safety gaps.

The third theme showed that participants had to unlearn perceptions that they were in the way of faster traffic. Our findings add a new angle to studies that have critiqued the valorization of speedy bicycling as reinforcing power relations (Aldred, 2015a; Popan, 2019; Psarikidou, 2020). Although assertiveness to take up space on two wheels was acquired through practice, not all participants were willing or had energy to negotiate pushback from other road users. Negotiating other bicyclists was a concern for those who bicycled in busy areas, as found in other studies (Freudendal-Pedersen, 2015; Poulos et al., 2019; van Duppen and Spierings, 2013). Clearly established norms or formal guidance to negotiate space with other bicyclists will become more important as bicycling grows in popularity.

The fourth theme highlighted that participants were already skilled in negotiating street harassment and assault. While some participants explicitly engaged strategies of avoidance (e.g., never bicycling after dark), others adapted personal safety practices to minimize street harassment while bicycling, such as altering routes. They identified these personal safety practices as specific to gender-based harassment rather than to bicycling, and furthermore pointed out that bicycling enabled them to escape harassment they might otherwise experience walking or on public transit. This illustrates how bicycles provided “partial and incomplete solutions” for participants to occupy unsafe streets (The Roestone Collective, 2014, p. 1360). Personal safety concerns are thought to influence women’s bicycling, but few empirical studies aside from Lubitow (2019) and Heim LaFrombois (2019) have examined concerns in detail. Our work contributes to this area by suggesting younger and racialized riders may be disproportionately impacted by harassment.

4.5.2. Comparing competences by phases of uptake and maintenance

Examining trajectories revealed a substantial competence discrepancy between rare bicyclists and other groups where participants were riding more regularly. These insights can inform future interventions for bicycle promotion. First, having a bicycle (material) as well as a basic level of handling skill was necessary before other competences became relevant. Second, development of bicycling skill takes time and

practice, but given supportive environments, people can take up urban bicycling with minimal previous experience. One-quarter of participants made short transitions from having not bicycled as an adult to using a bicycle for transportation, including two participants who had only learned to bicycle a few months before the course. The conditions that enabled participants to quickly transition to using bicycles for transportation included being able to access destinations on high quality bicycle infrastructure, and daily opportunities to accrue time in the saddle. Bicycling was most easily adopted and maintained when it bundled with and supported other practices in participants' lives, such as spending time with friends and family, or getting to work. By contrast, participants stopped bicycling when it was no longer feasible due to incompatible practices, such as needing to chauffer other people.

4.5.3. Identifying gendering processes in bicycling practice

While gendering processes shaped many aspects of bicycling, two stood out particularly strongly: competence acquisition and negotiating space. Feminine bodily comportment (Young, 2005) explained how taking up bodily space is learned and can be acquired through training and repeated practice, and we found similarities between safekeeping and defensive bicycling practices. Bicycle courses teach defensive practices, yet also subvert normative femininity by encouraging pupils to take up and command road space. Related to negotiating space, urban bicycling entails embodying, occupying, and being seen in space (Green et al., 2012). Participants here and elsewhere have underscored the masculinities of public bicycling space, such as the need to cultivate assertiveness or tolerate aggressiveness (Heim LaFrombois, 2019). These interactions occur in a "mobile space of norms, values, and power" (Jensen, 2013, p. 151) which potentially create unwelcome environments intolerant of slower or inexperienced bicyclists. For some, unpleasant interactions impacted their willingness to bicycle. Generally, participants with time in the saddle or supportive social networks were more resilient to withstand unpleasant interactions.

4.6. Policy recommendations

This exploration of competence and associated materials and meanings suggests several policy and practice recommendations to encourage underrepresented

populations (i.e., women) to start and maintain bicycling. For example, a primary barrier for women who rarely bicycled was obtaining a well-fitting bicycle. To complement bicycle skills courses, workshops on the bicycle buying process could empower first-time buyers (van der Kloof et al., 2014). Second, those who felt uncomfortable riding on streets shared with motor vehicles had limited opportunities to bicycle in supportive environments where they could develop handling skills. Courses with more sessions, including neighbourhood-based riding sessions, could provide further opportunities for practice alongside others. Third, our findings emphasize the importance of high-quality bicycling infrastructure to facilitate women's bicycling, and highlight that infrastructure be wide enough for faster and slower bicyclists to pass and be passed comfortably. Fourth, educating drivers about how and why bicyclists travel on shared roads builds shared understandings and can reduce motorist-bicyclist conflict (Bonham et al., 2018). Learning to share the road with bicyclists should play a much larger role in driver education so that it becomes a competence shared at a societal level (rather than small numbers of individuals who have taken a voluntary bicycle course). Fifth, education can likewise address divergent notions of what constitutes courteous bicycling behaviour and acceptable etiquette (Piatkowski et al., 2017). We suggest most people on bicycles want to be respectful of other road users, but there may be different opinions on how to best conduct oneself when bicycling. Raising awareness of behaviours that can be perceived as aggressive and alienating to other bicyclists may be a productive first step to build dialogue.

4.7. Strengths and limitations

We provide insights into competences women enact to bicycle in car-dominated cities. Our sample comprised women with diverse cultural backgrounds and bicycling practices, but was limited in socioeconomic diversity as most participants were university educated. Furthermore, although we had a diverse population in which less than a third of our sample identified as White, interviews did not deal with racialization in a substantive way, thus limiting our analysis of power and privilege. Given that our sample was drawn from a bicycle course, it is possible that participants were more concerned with traffic rules than others. Finally, the bicycle itself is fundamental to bicycling and participants identified necessary competences to obtain, park, and prevent theft of bicycles; these are topics for future work.

4.8. Conclusion

We identified aspects of bicycling competence learned by women at different phases of bicycling. Participants learned they were entitled to take up road space on bicycles and how to assert that space. Ongoing barriers to bicycling were shaped by issues of access, lingering uncertainty about interacting with other road users, and gender socialization of one's self-conduct in public spaces compounded by an underrepresentation of women bicyclists. We suggest the gender gap in bicycling reflects larger gender inequality, in line with other feminist literature (Heim LaFrombois, 2019; Lam, 2020). Bicycling in most cities entails claiming road space and thus an relearning of the physicality women are taught.

Chapter 5.

Riding alone and together: Is mobility of care at odds with mothers' bicycling?

Abstract

In most parts of the world, women bicycle less than men. One reason pertains to women's complex travel patterns, often associated with caring for children, especially so in places where bicycling is a marginalized mode of travel. This article describes how women begin or maintain bicycling during and following having children at home. We interviewed 17 mothers in Metro Vancouver, Canada, who aspired to increase or maintain their current amount of bicycling. We used Social Practice Theory to examine the interwoven elements (meanings, competences, materials), temporal aspects, and related practices that shaped bicycling. We found that bicycling held important meanings in terms of parenting, but that concerns of keeping children safe from traffic constrained where, when, and with whom women bicycled. Women with younger children had few opportunities to bicycles without children, whereas having older children or informal child care supports allowed women more opportunities to bicycle. Protected infrastructure and specialized bicycle equipment were vital to enable women to ride with children. Despite the promotion of bicycling in recent years in North America, many contexts are not yet conducive to bicycling with children. Various measures ranging from infrastructural improvements, flexible work hours, and sharing responsibility across the wider community for children's transportation, to bold disruptions to discourage driving will be needed to facilitate widespread adoption of using bicycles for trips involving chauffeuring and escorting.

5.1. Introduction

Cities around the world promote bicycle use as a sustainable and accessible form of transportation. However, in many places, there is a persistent gender disparity in bicycling. For example, in Canada, women use bicycles approximately a third as much as men (Butler et al., 2007), thus limiting women's transportation options and access to the potential health benefits to be derived from bicycling. This gender disparity is not

unique to Canada but is also seen in other countries with high car dependence and overall low levels of bicycling such as Australia, New Zealand, the UK, and the US (Garrard et al., 2012).

A number of studies have observed differences between men's and women's bicycling behaviour, but few have tried to account for what underpins the gendering of bicycling as a form of daily mobility. It is widely accepted that gender is an organizing feature of the social world. Parenting can reify gender differentiation and inequalities generated by cultural and economic forces. Surprisingly, few studies have examined how women with children bicycle with children in urban areas. This article considers the 'mobility of care' with respect to bicycling. Our analysis is informed by the feminist geography literature on women's transport issues which recognize mothers as carrying a disproportionate burden of travel with children. We draw upon Social Practice Theory to understand how bicycling fits into women's daily lives and the shared social conventions that shape bicycling in different contexts.

The aim of this paper is to describe how women begin or maintain bicycling during and following the time they have children living at home. We examine the complexity of bicycling practices among mothers in Metro Vancouver who completed an urban bicycle skills course, and the broader implications for a transition to more sustainable daily mobility. We differentiate how women use bicycles when bicycling alone, but also while being responsible for and travelling with children in an urban, car-dominated environment.

5.2. Literature review

5.2.1. Gender and mobility

Mobility and gender are co-constitutive (Hanson, 2010). Literature on childrearing and mobility shows that having children has profoundly gendered impacts on household division of labour and travel patterns (Scheiner, 2014). Both time-use and transportation studies demonstrate that chauffeuring (travel made specifically to transport others) and escorting (travel made to accompany others) are disproportionately born by mothers (Hjorthol, 2008) even in dual earner households (Boarnet and Hsu, 2015; Motte-Baumvol et al., 2015). In this article, we use the umbrella term "mobility of care"

(Sánchez de Madariaga, 2013) to account for chauffeuring, escorting, and other household maintenance trips such as food shopping. Incorporating a mobility of care lens is vital not only because caring labour is gendered, but because mobility of care has been shown to account for an equivalent proportion of trips as commuting (Sánchez de Madariaga, 2013).

Studies have documented a gender disparity in bicycling, with most focused on the influence of the built environment or safety perceptions. Compared to men, on average women have different preferences for bicycling routes, and are less inclined to ride on streets with motorized traffic (Aldred et al., 2016; Garrard et al., 2012; Mitra and Nash, 2018; Prati et al., 2019). Some researchers point to a tendency in the transport and bicycling literature to explain gendered patterns as 'natural' differences (i.e., women are more risk averse) (Bonham et al., 2015) rather than searching for gendering processes that render bicycling as more achievable for some people (Ravensbergen et al., 2019).

While the gendered nature of mobility of care has been well demonstrated in the driving literature (Best and Lanzendorf, 2005; Jain et al., 2011; Shirgaokar and Lanyi-Bennett, 2019) there has been less attention for bicycling. Mobility of care is often invisible in travel survey data for bicycling, where unpaid household labour is not measured (LeVine et al., 2014; Schoner et al., 2015) or bicycling mode share is too small to support complex analysis (Krizek et al., 2005). Presence of children in the household is often used as a proxy measure as to whether someone has caregiving responsibilities, and there is evidence that children in the household may be a greater constraint for women’s bicycling than men’s (Dill et al., 2015; Grudgings et al., 2018; Heesch et al., 2012; LeVine et al., 2014). However, research also suggests that bicycling with children is an incentive for women to start or return to bicycling (Bonham and Wilson, 2012b), perhaps more true for recreational bicycling than for commuting (Goodman and Aldred, 2018; Menai et al., 2015). Furthermore, the relationship between women’s bicycling and mobility of care is likely nuanced by women’s access to economic and mobility resources, and potentially split along class lines (Singleton and Goddard, 2016).

There has also been research into social and cultural factors that gender the meanings of bicycling. For example, assertiveness has different social connotations for

men and women, and the cultural meanings that make bicycling attractive to certain groups may not be equally prized in all families and communities (Steinbach et al., 2011). Other research has found that personal safety concerns pertaining to sexism and racism in public spaces, such as harassment, influence where and when women bicycle through the city (Heim LaFrombois, 2019; Lubitow, 2017). Such findings underscore the need to consider how gender intersects with other power structures such as class, racialization, and ableism (Lubitow, 2017).

A limited number of studies have explicitly examined how women use bicycles at different life stages, suggesting that social as well as physical environments are important. A London study found that women's decisions to continue bicycling into pregnancy were shaped by comfort and social support (Bennett, 2017). In Amsterdam, Eyer and Ferreira (2015) found that the main differences in bicycling between mothers and non-mothers were trip purpose and the times of the day that bicycle trips were taken, as mothers used bicycles for transporting children. A life course study with Australian women found that women often took breaks from bicycling during motherhood, as the bicycle was not practical for complex mobility of care travel (Bonham and Wilson, 2012b). These studies suggest that bicycling may "start-stop-start" for people throughout the life course in a cyclical rather than linear fashion. In this article, we use Social Practice Theory as a conceptual framework to consider how both physical and social environments influence how women are recruited to (start) or defect from (stop) bicycling.

5.2.2. Social Practice Theory

Social Practice Theory reorients the focus of behavioural study away from individual psychological attributes toward a greater emphasis on social context and conventions. To emphasize this distinction, the term "practice" is used over "behaviour". Studies using Social Practice Theory consider mobility practices—such as bicycling—to be embedded within the prevailing sociocultural organization of other practices, and irreducible to individual attitudes or choices. Social Practice Theory can also account for the relational dimension of mobility—essential to consider because individuals are embedded within social structures such as family and workplaces (Hanson, 2010; Manderscheid, 2014; Plyushteva and Schwanen, 2018)—as it situates mobility practices within social relations of everyday life. Practice-based approaches have been used to

understand the uptake and maintenance of bicycling (Aldred and Jungnickel, 2014; Larsen, 2018; Watson, 2012), but not to examine the intersection of gender and bicycling.

Social Practice Theory comprises a body of writings from various theorists and various conceptual aspects (Halkier and Jensen, 2011). Shove et al.'s (2012) conceptualization situates *practice* in relation to three connected elements: meanings that reflect norms and values; material things and environments; and competences such as know-how, knowledge and skills. The elements influence each other as practices emerge, shift, and cease when links between the elements are created, maintained, or broken. The configuration of these elements results in variation in practices across people, as well as across time and place (Hui, 2017). Predominantly, practices are woven together ("bundled") with other aspects of daily life (Shove et al., 2012). However, practices bundle more tightly, loosely, or not at all based on their temporal and spatial aspects (Cass and Faulconbridge, 2016; Shove et al., 2012; Watson, 2012). In this article, we use Social Practice Theory to: 1) situate participants negotiating a plurality of practices (e.g., parenting, transportation, work); and 2) understand bicycling as a relational accomplishment (i.e., involving other social relationships).

People can be recruited to or defect from practices. In this article, we are interested in how women are recruited to some bicycling practices over others, and how participation is sustained. Blue et al. (2016, p. 44) suggest that the likelihood of being recruited to a practice is contingent upon "what the practice itself demands and on previous life histories and resources (in terms of know-how, material elements, etc) accumulated along the way." Thus recruitment is also closely linked to inclusion in terms of access and participation opportunities. Some practices will be inaccessible for some people because of an unequal distribution of materials, opportunities to develop competences, or negative meanings (Meier et al., 2018).

5.3. Data and methods

5.3.1. Study design and setting

Vancouver's mild climate is conducive to year-round bicycling, and municipal policy and plans promote active travel, including bicycling (City of Vancouver, 2012b).

Within the city of Vancouver, the bicycle route network is relatively dense, consisting mainly of local street bikeways (shared roadways along local streets, typically traffic-calmed) (Winters and Zanotto, 2019). Across the region there are bicycle skills training programs to encourage bicycling growth. Children, families, and new riders are important target populations (City of Vancouver, 2016).

The qualitative study described in this paper forms the second phase of a mixed-methods investigation into the impact of urban bicycle skills courses delivered in Metro Vancouver. The quantitative approach assessed changes in bicycling frequency and confidence following the bicycle course, and the qualitative interviews examined processes associated with starting and maintaining bicycling. Given cities' desires to address the gender imbalance in bicycling, and that two thirds of bicycle course participants were women, we restricted interviews to women. The findings presented here draw from a subset of these interviews.

5.3.2. Participant recruitment and data collection

We recruited interview participants from a larger study cohort of adults who completed bicycle courses in 2016 and 2017 (Sersli et al., 2019b). In brief, these courses aimed to increase comfort level to ride in various urban environments, including on streets shared with cars, through teaching road safety knowledge and bicycle handling skills. All participants in the main study cohort completed online questionnaires. At the end of questionnaires, participants indicated if they were willing to be contacted for interviews.

From this pool we used a purposive sampling strategy to recruit a diverse sample of women in terms of bicycling uptake, number of years in Canada, and family status. Our primary intention was to develop a sample of participants who had increased any bicycling (transportation or leisure) post-course. We contacted 60 women by email: 20 did not respond, 8 declined, and 32 consented to and completed interviews. The final sample size was determined by the availability of respondents and resources. From the sample of 32 participants, this manuscript uses data from the 17 women who had children. Lead researcher (SS) conducted semi-structured interviews in 2018 (12-24 months after women completed bicycle training courses). She conducted interviews (45-120 minutes) in English at the research unit, participants' homes, workplaces, park,

library, or by phone according to participants' preferences. Audio-recorded interviews were transcribed verbatim by an external transcriptionist, and SS double-checked transcripts by listening to audio-recordings. All participants were given pseudonyms.

We began each interview with the question "Tell me about bicycling in your life, starting with when you first started riding a bike" and continued with questions pertaining to different trip types (commuting, errands, leisure), where and with whom participants bicycled, and their bicycle course. We probed for conditions that inhibited and enabled bicycling. Participants were aware that the purpose of the interviews was to ask about women's bicycling experiences; in the latter part of the interview, if gender had not been yet raised, we asked participants how they thought gender informed their bicycling practices. Appendix C includes the interview guide.

5.3.3. Data analysis

We followed an interpretive description methodology (Thorne, 2008) where we concurrently collected and analyzed data, constantly compared data within and across participants, and wrote memos throughout data analysis to identify gaps, record decisions, and document conceptual insights. We applied an iterative two-cycle coding approach (Saldaña, 2015). In this approach, first cycle coding aids with initial organization and sorting, and second cycle coding develops thematic concepts by reorganizing and condensing data from the first cycle. Through first cycle coding we generated holistic codes (the 'who, what, where, and when' as reported by participants), coded for emotions and values, and process coded (using gerunds to describe actions taken in response to situations). During second cycle coding, we used matrices to identify patterns and develop themes (Bazeley, 2009). Issues of caring, mobility of care, and mothering surfaced early in the study and required specific attention. To understand empirical findings, we compared a range of possible hypotheses with our data (Charmaz, 2008; Kennedy, 2018) and Social Practice Theory provided a well-fitting theoretical perspective. We used NVivo 12 for data analysis. The Simon Fraser University Research Ethics Board granted ethics approval for this study (2017s0653).

5.3.4. Methodological rigour

We employed various methods to facilitate rigour and saturation (Hennink et al., 2016; Morse, 2015). Prior to each interview the lead researcher (SS) reviewed the participant's individual longitudinal survey responses. The purpose of such preparation was to identify relevant questions to augment the standard interview guide and clarify reported patterns in bicycling and confidence. Immediately following each interview, she wrote field notes (Appendix E) with three aims in mind: first, to describe contextual information; second, to compare data to that collected in previous interviews; and third, to facilitate critical reflection. Critical reflection illuminated gaps and ambiguities in data collection, and was used to develop questions/probes for future interviews. Field notes also provided the basis for memos used to compare codes and identify preliminary patterns. She used member checking between participants (Morse, 2015, p. 1218) to generate richer data and insights. Following interviews, a second researcher (MW) reviewed field notes and transcripts. Lead researcher (SS) coded all transcripts. Early in the first coding cycle, a second coder recoded transcripts to ensure coding was consistent. During this and later analysis phases, the second coder acted as a "critical friend" (Smith and McGannon, 2018, p. 113) to discuss alternative interpretations of data. Throughout the analytic process, themes were discussed with other authors and colleagues.

5.4. Results

5.4.1. Participant background

Of the 17 mothers, 13 had children under 17 years of age living at home. Ten lived in the city of Vancouver and seven from neighbouring municipalities. Five women self-identified as White; the others as Asian, Latina, West Asian, or mixed ethnicity. Five women had been living in Canada for less than five years. Most (12/17) had university degrees. Mobility/transportation circumstances varied in the sample. While most women (16/17) lived in households with one or more cars, three women did not have drivers' licences. The majority (14/17) used a variety of transportation modes in an average week while two relied primarily on the car and one rarely travelled by car.

The women's bicycling experiences were diverse (Table 5.1) and few had bicycled continuously throughout their life. All had learned to bicycle as children, but only a handful continued bicycling during their teen years. Women picked up bicycling again at different points. For some, it was in their 20s (influenced by partners or a sports club). Others had only recently returned to bicycling. Life events had different impacts on bicycling: some women stopped when they had children; others started again after having children. Some started again upon relocating to Vancouver whereas women from China (a country with historic high levels of bicycling) found it more difficult to bicycle in Vancouver. At the time of interviews, approximately half the women were using their bicycles at least once per week. In terms of trip purposes, some women bicycled exclusively for transportation, some exclusively for leisure, and some for both. The types of bicycling women were able to accomplish when accompanied by children were far narrower: with a few exceptions, women did not use bicycles for transportation when accompanied by children, rather, they bicycled for leisure.

Table 5.1 Participant bicycle biographies

Participant	Brief bicycle biography	Children
Sam	Learned to ride as child (Canada). Started bicycling again after birth of second child (errands). Currently bicycle for errands and starting to ride to work.	2 (ages 0-5)
Asha	Learned to ride as child (Canada). Started bicycling again after bicycle course (commuting). Currently not bicycling.	1 (age 0-5)
Tracy	Learned to ride as child (Canada). Bicycled to work in 20s; stopped after child; started bicycling again after bicycle course (errands, work). Currently not bicycling.	1 (age 6-12)
Dina	Learned to ride as child (Iran). Started bicycling again after bicycle course (errands). Currently bicycle for errands.	2 (ages 0-5, 6-12)
Lin	Learned to ride as child (China). Started bicycling again after birth of fourth child (work, errands). Currently bicycle for errands and for leisure.	4 (ages 0-5, 6-12)
Andi	Learned to ride as child (Canada). Bicycled on and off throughout life. Currently bicycle for leisure.	1 (age 6-10)
May	Learned to ride as child (China). Bicycled throughout life. Currently bicycle for errands and for leisure.	3 (ages 0-5; >18)
Julia	Learned to ride as child (Canada). Bicycled in her 20s; started bicycling again with family. Currently bicycle for leisure.	3 (ages 6-10, 13-17)
Sofia	Learned to ride as child (Mexico). Bicycled in her 20s; started bicycling again with family. Currently bicycle for leisure and starting to ride to work.	3 (ages 6-12)
Maggie	Learned to ride as child (Canada). Bicycled in her 20s, mainly leisure. Currently bicycle to work.	1 (age 6-12)
Lucia	Learned to ride as child (Philippines). Currently bicycle for leisure.	1 (age 13-17)
Gloria	Learned to ride as child (Philippines). Started bicycling again with family. Currently bicycle to work, for errands, and for leisure.	1 (age 13-17)

Participant	Brief bicycle biography	Children
Kim	Learned to ride as child (Canada). Did not bicycle after course. Currently not bicycling.	2 (ages 13-17, >18)
Sharon	Learned to ride as child (China). Bicycled throughout life. Currently bicycle for errands and for leisure.	1 (age >18)
Beth	Learned to ride as child (Canada). Started bicycling again in her 20s (leisure, work). Currently bicycle to work.	2 (ages >18)
Sandra	Learned to ride as child (Canada). Started bicycling again five years ago (work). Currently bicycle to work.	4 (ages >18)
Leila	Learned to ride as child (Iran). Started bicycling again after bicycle course (leisure). Currently not bicycling.	2 (ages >18)

Applying Social Practice Theory, we identified four themes in the interview data: 1) meanings, or the values associated with bicycling; 2) competences, or strategies to increase skills and confidence; 3) materials, the physical conditions that shaped bicycling; and 4) temporality, or negotiating schedules and time due to work and caregiving. Although the themes are presented as distinct, they were always interdependent and woven together, and we emphasize where meanings, competences and materials are co-produced. Further, we differentiate bicycling accompanied by children (co-bicycling) as a distinct practice from bicycling alone.

5.4.2. Theme 1: Meanings of bicycling and parenting

Interviews were rich with the "meanings, ideas, and aspirations" (Shove et al., 2012, p. 14) that participants attached to bicycling. Participants expressed values generally supportive of bicycling regardless of parental status, including fitness, independence, a transportation alternative, and a smaller carbon footprint. For mothers, the bicycle took on particular meanings relating to parenting. Quotes illustrate meanings related to quality family time, setting a good example, teaching life skills, and unsafe streets. Bicycling was seen as a pragmatic healthy activity for mothers themselves and for their children, and for most, an enjoyable family activity, in line with other studies (Bonham and Wilson, 2012b). Women described co-bicycling as a way of travelling together to a nearby activity or venue, such as the swimming pool or library, or as a fun leisure activity. Gloria described bicycling with her partner and daughter as a weekly family ritual: "it's fun to do it and it brought our family closer 'cause it's a way for us to wind down after a week's work." Gloria demonstrates how people may be receptive to

adopting bicycling practices that enable other socially valued practices, such as family time.

A number of women remarked that bicycling was a means to model values such as independence and transportation alternatives to their children. Sam, who started using a cargo bike to transport her small children places explained:

> I don't like the idea of them being driven around all the time. And I think that showing them how to get around on their own, like on a bicycle or on transit, is important for them becoming more independent just generally. So for me that's good mothering.

Maggie saw bicycling as modelling twin values of a greener footprint and physical activity: "I think it's a good example to help her see a way to use a car less when she's older … you know, just showing her that's my way of trying to stay fit and also to drive less." These values were expressed even by women with very young children, and mothers often made reference to setting good examples. Asha, experimenting with bicycling to work after not having ridden for many years, wanted her toddler daughter to one day be more comfortable using a bicycle than she was: "My daughter would see me leaving on my bike or coming home on my bike. And that made me feel really proud. Like I'm setting a good example for her."

Other women recounted bicycling as something they did as children and wanted to pass on. Beth, a long-time bicycle commuter, explained: "So growing up skiing, cycling, swimming … things [you did] as a kid and then as an adult you want to continue that. … And then you want to instill that in your kids". A few women said it was time to teach their children to ride a bike and described the importance of enabling their children to develop physical skills. Explaining how she wanted her child to develop skill sets missing from her own childhood, Andi said: "I think it really depends how you're raised. That's why I wanted to teach my son, like, how to swim, how to ride a bike, how to do things that I think are really basic." Other researchers have described this sentiment as "parents taking on responsibility for ensuring that their children develop the 'right' skills/abilities at appropriate times" (Stirrup et al., 2015, p. 92). In our study, mothers felt responsible for ensuring their children's competence to bicycle in urban environments, and that the children had the skills to support this.

Women described a tension between bicycling and keeping children safe from traffic danger, pertaining to meanings in what others have described as the 'good parenting ideal'. Holt et al. (2016) describe the good parenting ideal as how parents strive to fulfil contemporary parenting norms, arguing that what constitutes good parenting is socially constructed and changing over time. Intersecting with a culture of anxiety concerned for children's safety in public spaces, they suggest that contemporary 'good parenting' entails time-intensive parental involvement and monitoring of children's play coupled with children's participation in structured out of home activities. For participants, encouraging bicycling was seen as good parenting for health, environmental, and developmental reasons outlined above, while conversely, urban streets were not seen as safe places for children. To ease this friction, mothers escorted their children by bicycle, a trend noted elsewhere (Eyer and Ferreira, 2015; Schwanen, 2011). In some instances, the necessity to escort children encouraged women to remain engaged with bicycling. In other instances, mothers had limited time to supervise bicycling but felt it was irresponsible to let children ride unsupervised. Broadly, restricting children's bicycling felt contradictory to their other good parenting values.

5.4.3. Theme 2: Competences to ride alone and with children

Places where bicycling is marginalized require specialized types of competences (Aldred and Jungnickel, 2014; Larsen, 2016). The bicycle course our participants had taken was designed to address competences ("skill, know-how, and technique" (Shove et al., 2012, p. 12)), specifically the confidence to bicycle in urban environments. Many participants enrolled in the course to boost confidence. Although all participants had learned to bicycle earlier in life, some were unaccustomed to sharing road space with cars. Several of these participants remained reluctant to bicycle on roads after the course, although they were cognizant that more time spent riding on roads would build their confidence.

5.4.3.1 Keeping children safe from traffic

Women described bicycling with children to require additional competences. Several women referred to techniques for managing extra weight and momentum when carrying children on bicycles. The physical skills needed to bicycle with children were far more easily acquired than confidence to bicycle with children on streets shared with

cars. Asha felt unable to continue bicycling when she resumed responsibility for taking her child to daycare:

> when I see people, particularly with the trailers, I kind of go, 'Wow' and then I kind of go, 'Whoa.' Because it's scary … it's that type of fear, particularly not being that experienced, that holds me back for sure.

By contrast, when Sharon lived in China she bicycled throughout pregnancy and with her small baby. She described bicycling in China as "slow", with comfortable bike paths separated from cars, where she did not experience fear or concern. We expand more fully where competence intersected with materials in Theme 3.

Participants noted that discomforts they may experience bicycling on urban streets were magnified when they had children with them. For some, the primary reason they sought a course was to enhance their confidence and safe bicycling knowledge so that they would feel more confident bicycling with children. Julia, a proficient mountain-biker in her youth but just starting to bicycle on streets in her neighbourhood, explained:

> that's why I ended up taking that course, because I wanted to be more confident to ride on the roads … I would never want to go [bicycling in the neighbourhood] with my kids because I myself was not confident.

Andi, who described herself as an unconfident rider, expressed the desire to model confidence, "I don't want to pass my bicycling problems onto my son." Both quotes illustrate that competence is intertwined with notions of good parenting. To ensure their children were exposed to bicycling and had opportunities to ride bicycles, these mothers sought to build their own bicycling confidence.

5.4.3.2 Family bicycling: a potential competence pathway?

Some women who engaged in family bicycling (riding with children together with partners or other family) on a regular basis developed competences to start bicycling in other contexts. Gloria recounted the start of a family bicycling ritual initiated after they moved to Canada:

> So we bought a seat for babies at the back, and [put our baby on] the bike of my husband. … we do it, like, as a family thing for leisure and we go to the park. We used to live nearby a park, so we go biking. … That's how we started.

After years of weekend family bicycling, Gloria attended a bicycle course with her family to provide herself and her teen daughter the confidence and skills to bicycle independently for transportation.

Similarly, after bicycling with her family for several years Sofia was beginning to bicycle commute. Family bicycling had developed Sofia's competences to bicycle independently to work, but not the competences required to bicycle with children on her own. She explained that she was only confident to bicycle with her children when her partner was there, and did not relish the prospect of bicycling alone with her children:

> So it will be one adult dealing with three kids. One will be attached to my bike, so I know she will be okay unless she falls asleep and falls backwards without my awareness. … And [it will also] require a lot of yelling to my older kids to be careful. To watch out for their surroundings, to keep in one line, not to cut off, all these little things.

5.4.4. Theme 3: Materials and mobility of care

With respect to materials participants felt strongly about bicycle infrastructure, especially so when bicycling with children. Women with young children had few opportunities to bicycle alone.

5.4.4.1 Geographic restrictions when riding with children

Bicycling with children on streets was a source of tension, as found elsewhere (Bonham and Wilson, 2012b; Clayton and Musselwhite, 2013). Women said that routes fine for themselves were not suitable for children, mirroring other findings (Aldred, 2015b). Parts of the on-road bicycle network, despite being designated bikeways, were considered unsafe for travelling with children. Parked cars, narrow streets, and negotiating car drivers contributed to the stress. Sofia described Ontario Street, a well-travelled designated bikeway: "I think by myself it will be okay. But with kids, I don't think it will be as safe. It's just too narrow and too many cars zig-zagging in and out through the parked cars." The ideal spaces to ride with child cyclists were protected from cars, along separated paths or traffic-free areas. Where bicyclists had to share streets with cars on local street bikeways, women preferred routes that clearly gave bicyclists the right of way, had cars travelling slowly, and intersections that permitted adequate crossing time for child cyclists.

Women's willingness to negotiate shared streets on local street bikeways may have been shaped by whether children were carried ("child passengers") or riding their own bicycle ("child cyclists"). It was most difficult bicycling with children who were too big to be carried, as reported elsewhere (Chatterjee et al., 2013; Eyer and Ferreira, 2015). Given issues of wobbliness and unpredictable movements, women with younger child cyclists tended to be limited to traffic-free areas, such as parks, protected bicycling infrastructure, or sidewalks.

The challenge of bicycling with child cyclists is one reason why few participants used bicycles for short-distance errands, such as taking children to the library or school. For example, Maggie (herself a bicycle commuter) drove her daughter (age 9) to school as she felt the roads were too busy with traffic in the morning to co-bicycle the short distance. Only two mothers with child cyclists under 12 years—both immigrant mothers without ready access to cars—made these types of errand trips regularly. Lin, who grew up using a bicycle in China, bicycled with her older children (ages ranged 6-10 years) to sports practice and the library on weekends, using quiet routes. Similarly, Dina lived close to a protected bike lane which she used to escort her child (age 11) to school most days. She described this route as "comfortable" and "convenient".

5.4.4.2 Material matters: access to equipment and safe places to ride

Access to child seats, trailers, cargo bicycles, or other devices to carry children seemed to broaden the types of routes where women could bicycle with children. However, this brought additional costs. May, recently moved from China, found bicycle equipment in Canada unaffordable:

> I bought my bicycle. There's only a bicycle, not anything [else]. Not [a rack], not the basket. You know in China [when] you buy a bike or bicycle there is everything. [Here] if I want a [child seat] it's very expensive.

Cargo bikes have been suggested as a means to overcome mobility of care barriers (Riggs, 2016), but the cost of cargo bikes, even second-hand, remains out of reach for many.

The theme of materials and mobility of care further illustrates that bicycling with children not only required new competences, but that competences were linked to the type of materials (infrastructure, equipment) available. Competences and materials

shaped the types of bicycle trips women made with children, which in turn shaped the personal meanings women attributed to bicycling. Having used a bicycle as her main transport in China, May conveyed the frustration that led her to “give up” bicycle commuting in Canada. Currently confined to leisure bicycling due to a perceived lack of bicycling infrastructure, she remarked, “Before in China I think bicycle is a transport vehicle. But now I will change my mind to bicycle as a hobby.”

5.4.5. Theme 4: Temporal constraints for mobility of care

Time constraints were mentioned across the interviews. Here we examine how women accomplish bicycling within household rhythms.

5.4.5.1 “Pieces have to fit”: the alignment of schedules

Complex commuting trips were not easily accomplished by bicycle. All participants were employed outside the home. The majority regarded bicycling to work as an opportunity to squeeze coveted exercise time into busy lives (Larsen, 2016), and some found bicycling to be a faster alternative than walking or taking transit to work. However, delivering and picking up children from daycare, school, or after school activities was challenging for women to accomplish in addition to bicycling to work. When women did bicycle commute, they tended to bicycle alone. Women with younger children managed this through two strategies. Some walked or drove children to school, and then returned home to bicycle to work; this worked when destinations were close, or work start times were flexible. Others had support (e.g., parents, partners) to share the task of child transport, which freed women to bicycle to work; however, this was not an option for many in the sample.

Scheduling was complex. Sam described the necessary alignment of child-care and work schedules of herself and her partner to enable bicycle commuting: “Pieces have to fit and when our daughter got the after-school care and my son got that daycare, then it was, like, those are the pieces." “Pieces have to fit” illustrates how bicycling is relational and interdependent, bundled with other practices involving other people and other spatiotemporal dynamics. Women with teenage and older children found it easier to bicycle commute when children became independently mobile. Beth found it easier to maintain a routine with adult children:

> I'd say the last few years that my kids have been older and I've gone to [new working hours] … the last ten years I've been really consistent. Yeah. But before that I guess it was more sporadic 'cause-- having the kids and stuff.

Her experience resonates with findings from studies of transportation across the life course (Lanzendorf, 2010).

The period *before* children and teens were independently mobile—especially as they became involved in extracurricular activities farther from home—made bicycling to escort children places less feasible and taking the car more attractive. Sofia, mother of three, listed concurrent car trips taken by herself and her husband to pick up children from different sports practices across town. Children's extracurricular activities are often accomplished by car (Hjorthol & Fyhri, 2009; Lagrell, Thulin, & Vilhelmson, 2018). Some participants without access to cars limited activities. For example, with no drivers' licence, May described the difficulty of accessing programs that were not on routes she could bicycle with her son. She noted she was only able to apply for programs close to home.

5.4.5.2 The time-crunch limited bicycling

Mothers were often pressed for time, negotiating tight schedules between work and mobility of care. A few mothers suggested chronic time constraints curtailed opportunities for bicycling, as found elsewhere (Bonham and Wilson, 2012b). Julia recounted her hectic days: "I'm literally rushing home from work so that I'm home for 15 minutes and then I got to drive this kid out to [an activity]". She later iterated, "So unfortunately for me, like, we're really quite crazy, our schedule. It's just finding the time … rush, rush, rush, which is sort of sad, really. You know, the rat race, they say". The "rat race" was seen as incompatible with bicycling for transportation and it also limited leisure opportunities. Mothers dealt with chronic time constraints by using cars, which they did not like, but felt they had few alternatives. Andi, who aspired to a car-lite lifestyle, explained: "The days are … so packed already that I'm even … driving, like, six blocks, ten blocks just because we're in that much of a hurry all the time". She further suggested that societal restrictions around children's independent mobility placed additional onus on parents to be ever present to pick up and watch children:

> So I started letting [child walk] unaccompanied a lot earlier than most of the people that I know … but any activity that he's at they don't kind of just let

> him come and go … at [extracurricular activity], he can't be there early. He can't be there late. He can't be more than five minutes on his own.

She felt that it was important for her son to have enriching activities, but felt the increase of her chauffeuring burden.

5.5. Discussion

This work advances our understanding of how women with children who are motivated to bicycle, adopt, adjust, or cease bicycling over time. From interviews with women who had taken a bicycling course, we uncovered how the ages of children, safety concerns, parenting norms, and time constraints intersected with infrastructure to shape bicycling practices. The majority of participants regarded the bicycle as a suitable transportation alternative for themselves, but less so when travelling with children. Most found it stressful and unpleasant to bicycle on city streets with children and sought places with the least traffic. This meant some were limited to leisure bicycling. Mothers with older children reported that reduced mobility of care obligations loosened their time-space constraints so that they were able to establish regular bicycle-commuting patterns. Cargo bikes, protected bike lanes leading to schools and other places, and child care support enhanced women's bicycling participation.

To make sense of women's diverse bicycling behaviours, we used Social Practice Theory. We conceptualized bicycling for different trip purposes and bicycling with or without children as distinct practices requiring different social (i.e., meanings, competences) and material conditions. The concept of distinct practices explained why bicycling varied within a single person over time, as she adapted to new conditions and contexts, as well as across women sharing similar characteristics.

5.5.1. Understanding bicycling through Social Practice Theory

Social Practice Theory provides insight into how practices are performed, by whom, and when. These insights can inform interventions to address a wide range of social and material conditions constituting bicycling (Spotswood et al., 2017). The interdependent nature of meanings, competences, and materials illustrated in this paper underscores the importance of comprehensive policy packages to shift behaviour. For participants with children aspiring to bicycle more often, the material condition of

infrastructure was often the primary constraint, but for others temporal conditions were also important. A practical application of our findings is to demonstrate opportunities for intervention through identifying missing and existing links between elements. For example, for some participants, the material condition of infrastructure shaped particular meanings (e.g., bicycling as stressful or not safe) which shaped the types of competences required to bicycle. There is already considerable evidence demonstrating the importance of infrastructure on bicycling rates and perceptions of safety, and an obvious intervention for planners would be to continue enlarging and upgrading the city's bicycle network. For other participants, bicycling as a family ritual engaged them in leisure bicycling and gradually developed their confidence to bicycle for other trip purposes. Learning from their experiences, potential intervention opportunities might thus involve promoting family-based exploration of the city using the bicycle network.

We next used the concept of practice bundles to examine how mobility of care practices bundled with transportation and leisure bicycling practices, what others have termed 'practice/mobility bundles' (Spurling and McMeekin, 2015). Whereas bicycle commuting (alone) was an attainable practice for some, accomplishing bicycle commuting or errands when accompanied by children was less so. Our results point to specific spatiotemporal challenges arising from transportation bicycling and caring for children. These pertain to distances needed to access children's extracurricular activities, availability of daycare, parenting norms, and gendered patterns of care (i.e., women being primarily responsible for care during the work week). Women's work and caregiving responsibilities entailed careful choreography of bicycle trips around the household schedule. These empirical findings have both theoretical and practical contributions. By explicitly incorporating practice/mobility bundles in our analysis we highlight systemic processes that enable or hinder bicycling, and explain variation more richly than comparing only demographic differences between participant groups. Our results contribute to recent work on how practices within bundles are negotiated (Hui, 2017; Scheurenbrand et al., 2018), as well as recent work on practices and temporality (Mylan and Southerton, 2017). Further, the application of practice/mobility bundles can be important for policy analysis as it reveals conflicts and harmonies between practices. Consideration of where bicycling linked or failed to link to other areas of participants' daily lives underscores the need to consider a broader range of social factors that are known to gender mobility. To address these practice/mobility bundle conflicts,

interventions may need to encompass factors “seemingly unrelated” to bicycling (Spurling and McMeekin, 2015, p. 91).

To increase bicycling for transportation, bicycling must be compatible with other related practices (Aldred and Jungnickel, 2014) including those overlapping with mobility of care. Cities will need to invest in multi-pronged approaches to remove barriers to bicycling with children. Many of these pertain to the built environment, squarely within urban planning purview, for example land use practices to promote shorter distances and street design to enable safer routes. Creating accessible bicycling environments for all ages and abilities is a policy goal in Vancouver and other cities, yet participants thought there were few spaces throughout the city where children could bicycle safely, even when accompanied by adults. The majority of traffic-free spaces in Metro Vancouver are located in parks and on recreational trails. This explains why bicycling with children was often practiced by participants as a leisure rather than transportation mode. An implication of this work is that to encourage mobility of care trips made by bicycle, high quality infrastructure improvements need to be situated around places that people with children go, for example, schools, daycares, and community centres.

We briefly discuss two other findings, temporal and safety concerns, thought to be “systemic sticking points” (Watson, 2013, p. 125) to transition away from cars to more bicycle use . The first, being pressed for time, was seen by some participants as incompatible with bicycling, and research suggests that temporal constraints may be experienced disproportionately by women with children as they manage the task of coordinating multiple schedules (Southerton, 2007). Incorporating a temporal lens enables new insights into challenges and opportunities for bicycling uptake. Cities can utilize a suite of planning tools to enable bicycles to travel faster and more directly to destinations than cars. In this way, reaching destinations by bicycle becomes more practical. The second, current social norms regarding children’s safety and risk in public spaces, contributed to both burden of and extent to which participants could accomplish mobility of care by bicycle. This too can be addressed by planning and policy. A shift away from car dominance—where people moving at slower speeds are granted priority over car drivers, and where driving is less easy to accomplish than walking, bicycling, or taking public transportation—can shift this social norm (Larouche et al., 2018). It would also more equitably distribute the responsibility of safety and risk across the wider community.

Our results suggest addressing social norms are necessary but insufficient on their own when isolated from material conditions needed to shift practices. Most participants were aware of the car's negative consequences and spoke of a tension between encouraging active travel while relying on the car to fulfil their caregiving responsibilities. Some women wanted to make more of their trips by bicycle, but felt locked into using cars because of larger structures, norms, and material contexts. Relatively few women drove children to school or daycare, but children's extracurricular activities were often too far or too late in the evening to consider bicycling a feasible travel mode. However, not all participants regarded cars as necessary to successfully parent. Mothers without easy access to cars—mainly immigrant women—organized their lives around walking, transit, or what they could reasonably bicycle. This suggests that bold disruptions to driving ("sticks") supplemented with support for alternative modes ("carrots") are needed to foster new links between social norms and competences favouring active travel.

5.6. Strengths and limitations

Our study fills important gaps. While there is a body of scholarship on encouraging children's bicycling, our analysis uniquely focuses on the experiences of mothers, who directly shape children's mobility. The sample comprised participants with diverse cultural backgrounds and bicycling practices. Within the interviews we completed, these were consistent and repeated themes, suggesting saturation was met. Of course, mothers in different places, or with different life histories, may or may not share these perspectives. We put substantial effort into recruitment, with multiple contact efforts, and conducted interviews at times and places preferred by participants. However, only about half who were invited participated, and it is possible these are mothers most interested in cycling. We did not delve into processes as to why women in our sample were predominantly responsible for mobility of care during the week, nor did we examine the processes as to why immigrant women in our sample had fewer financial resources than their Canadian-raised counterparts. Finally, we interviewed only women, given the interest in gender inequities in who cycles, as well as who participated in courses. Further studies may consider men's mobility of care bicycling experiences.

5.7. Conclusion

In sum, mobility of care should be considered a vital aspect of transport and urban planning, as has been long argued by feminists. As cities increasingly promote bicycling as a transportation option, we must consider how those who care for children—both men and women—are able to transport children by bicycle. This article highlights the achievements and barriers that women who are already motivated to bicycle experience. We have shown that given the right conditions, participants in our study were able to use bicycles in urban environments for themselves and their children. When safety concerns were addressed, participants benefitted from more mobility options and access to opportunities. Their experiences are useful when considering the potential for population shifts toward active travel.

Chapter 6.

Conclusion

6.1. Overview

Cities worldwide are promoting urban bicycling. Although developing supportive bicycle infrastructure is a necessary precondition for most people to begin riding (Pucher and Buehler, 2017; Winters et al., 2017), other forms of encouragement are also needed to spur bicycle uptake across populations. Women have become an important target group for bicycling promotion, as they participate in bicycling at roughly one-third the rate of men (Buehler et al., 2020; Garrard et al., 2012; Shaw et al., 2020) yet make more short trips that are potentially feasible by bicycle (Mitra et al., 2016; Shaw et al., 2020). Despite the well-documented gender gap in everyday bicycling, studies suggest there is substantial appetite from women to start bicycling or to bicycle more often (Rissel et al., 2010; Sustrans, 2018).

Traffic safety concerns pose the primary barrier to urban bicycling for most people in low-bicycling contexts (Aldred et al., 2017; Heesch et al., 2012). Given that many cities are still in the process of creating dense, connected, and high quality bicycle infrastructure, urban bicycling demands a certain level of skill and confidence to share streets with cars. Bicycle skills training courses ("courses") are promoted as a cost-effective way to increase bicyclists' confidence, perceived safety, and awareness of traffic rules (Nachman and Rodríguez, 2019; Sherriff, 2014). Together with supportive infrastructure and changing social attitudes, experts suggest that bicycle skills training can potentially increase ridership (Pucher et al., 2010) and encourage women's bicycling participation (Bekkum et al., 2011; Lam, 2020). However, despite broad enthusiasm for bicycle skills courses, there are limited studies that have examined the impact of courses on adults (Johnson and Margolis, 2013; Pucher et al., 2010).

This mixed methods dissertation examined the impact of bicycling skills training courses on bicycling participation, and the broader processes that enabled bicycling for women of diverse backgrounds before and after participating in a course. I used questionnaire and interview data collected from people who registered in a bicycle skills course in Metro Vancouver, Canada—an urban environment that has been promoting

bicycling and extending its bicycle infrastructure. Specifically, the chapters in this thesis address gaps in our understanding if and how courses increase bicycling, the extent to which courses support women's bicycling participation, and further actions that can be taken. The chapters form standalone peer-reviewed publications, and accordingly contain policy implications and conclusions respectively. In this concluding chapter, I discuss the main findings of my dissertation research, the contributions of this dissertation to the literature and practice, its limitations, and directions for future work.

6.2. Summary of findings

Chapter 2 presented a scoping review to identify and describe evidence of change in bicycling participation associated with bicycle skills training for children or adults. Bicycle skills programs have been implemented in numerous countries, cities, and schools to promote bicycling as a form of active travel, but few evaluations of these programs have measured bicycling participation as an outcome. With limited evidence, it is difficult for practitioners to identify successful programs, or to estimate realistic program targets. Compiling results from 12 studies, the scoping review found some studies reported increases in bicycling as a result of the training. The review identified components of successful programs. It also provided strategies to improve reporting on intervention theory and context, as it found that studies generally provided scant details about these. Descriptions of intervention theory and context can help determine why the same bicycle skills training program may have a sizeable impact in community A but very little impact in community B.

Chapter 3 examined the impact of a community-based bicycling training skills program delivered in Metro Vancouver. It measured increases in bicycling frequency and confidence over one year. We compared intervention participants with a comparison population and examined the number of days participants reported using bicycles for different trip types. At the time the study was designed, quasi-experimental designs (i.e., using comparison groups) were rarely used in active travel research, and this work represents one of the first attempts to do so. The study is unique in that it uses multiple follow ups over a 12 month period (relatively long compared to similar studies), and has an outstanding (99%) retention rate. We found that participants bicycled more frequently for commuting than for either errands or leisure, but the highest participation rates (i.e., if participants bicycled at all) was for leisure. One year after the course, we did not see

lasting increases in bicycling. However, we did find a modest short-term increase in leisure bicycling one month after the course. We also examined changes in confidence pertaining to bicycling on streets with cars, using maps to find routes, or knowing about safe routes, but found no lasting effect of the program on confidence.

The final two chapters (Chapter 4 and 5) drew upon interviews with a subset of women participants (n=32) who completed the bicycle skills course. These chapters apply Social Practice Theory and gender frameworks to understand underlying processes—sociocultural and power structures—influencing bicycling uptake and maintenance across and between women. Chapter 4 examined the bicycling competence (skills and know-how) needed to ride in Vancouver. Participants described skills for road positioning and route-finding, knowing formal (laws) and informal rules (etiquette) to interact with other road users, and having strategies to minimize gender harassment. Women with opportunities to engage in bicycling cultivated competences more quickly. Those without suitable bicycles rarely rode; others described a virtuous circle where more time bicycling led to greater confidence. Gendering processes shaped nearly all aspects of bicycling and included safekeeping (taking disproportionate personal responsibility for safety) and cultivating an assertive bodily comportment to take up space. This work represents one of the first studies to apply Shove et al's (2012) three-elements model to a bicycling promotion intervention. The application of the three-elements model illustrated how context interacted with the intervention to enable (or not) women's bicycling. Chapter 4 is also one of the few studies to reconcile gender theory with Social Practice Theory. Social Practice Theory has been critiqued for insufficiently theorizing power (Watson, 2016). Pairing these two theoretical approaches allowed for a more fulsome analysis of structural power relations reflected in bicycling.

Finally, Chapter 5 examined how women begin or maintain bicycling with dependent children in the home. We found that bicycling held important meaning in terms of parenting, but that concerns of keeping children safe from traffic constrained where, when, and with whom women bicycled. Women with younger children had few opportunities to ride without children, whereas older children or having informal child care supports allowed women more opportunities. Protected infrastructure and specialized bicycle equipment were vital to enable women to ride with children. By specifically focusing on the experiences of mothers and their caregiving responsibilities,

this analysis addresses a notable gap in bicycling research despite the well-known bicycling gender disparity.

6.3. Significance and contribution

This dissertation deepens our understanding of how bicycle skill courses contribute to behaviour change. Many cities, including Vancouver, have been investing in bicycling infrastructure. The studies in this dissertation contribute to a better understanding of how bicycle skills training might enable individuals to benefit from these infrastructural investments. Viewed as a whole, the results of chapters 2 and 3 suggest that while courses may facilitate modest short-term increases in leisure bicycling, the results of chapters 4 and 5 emphasize that for even for a subset of women motivated to start and remain engaged in bicycling, other elements of the social and physical environment did not support the full variety of journeys they needed to make. Taken together, this emphasizes that bold expansion of the bicycle route network, supplemented with more intensive training and practice sessions for new and returning riders, will be required to support the majority of women to engage in transport bicycling.

The use of a mixed methods design provided several advantages. The quantitative arm (questionnaires) enabled me to examine change over time among 178 participants—a larger number than would have been feasible with interviews. It also permitted me to acquire demographic information for HUB Cycling about who enrolls in their bicycle skills courses (chapter 3), as HUB does not systematically collect this information. The qualitative arm (interviews) allowed me to explore trends seen in the quantitative analysis. I could obtain richer information about the influence of the bicycling training course, as well as contexts that influenced participants' bicycling opportunities and constraints. Interviews enabled me to ask participants about their bicycle biographies (life histories) and processes by which they were able to initiate and sustain bicycling. Interviews also enabled me to more deeply interrogate gender and bicycling.

Another contribution of this thesis was the use of two different behaviour change frameworks, the Behaviour Wheel Change system and Social Practice Theory, to examine behaviour change and program design. Conceptual and epistemological tensions between these frameworks aside, there were also productive and complementary intersections. Both frameworks account for the physical (i.e., built

environment) and social conditions shaping behaviours. In chapters 2 and 3 I used components of the Behaviour Wheel Change system (Behaviour Change Techniques, or BCTs) to describe intervention content and facilitate comparison. In chapter 3 I used BCTs to reveal potential places where courses could be strengthened, and highlight the absence of providing social or physical opportunities for bicycling. I was then able to more fully explore social and physical opportunity for bicycling during interviews. In chapters 4 and 5 I used Social Practice Theory to further enrich the interaction between individual and structure, and intervention and context. The concept of practice bundles was invaluable to help understand why bicycling was more readily and repeatedly enacted by some participants than others. Chapter 5 contributes to the empirical application of Social Practice Theory in intervention design.

Much bicycling research focuses on existing bicyclists (Caldwell and Boyer, 2018; Handy et al., 2014). This dissertation was able to follow a population of largely infrequent (approximately half of participants in chapter 3), or new and returning riders (nearly half of participants in chapter 4), using a longitudinal design to assess changes over time. Infrequent riders are a prime target for behaviour change interventions aiming to shift modal share toward more active travel (Piatkowski and Marshall, 2015; Winters and Teschke, 2010). My work creates new knowledge about how this important group initiated and sustained bicycling, their ongoing barriers, and what further intervention is needed.

The dissertation finds a reciprocal relationship between bicycling and confidence and calls into question the linear pathway assumption of behaviour change models prevalent in planning, such as the Theory of Planned Behaviour (Kroesen et al., 2017). Chapter 3 found that confidence, but not bicycling frequency, increased after taking a bicycling course. Interviews were able to clarify this relationship as cyclical, described in chapter 4. My work contributes to a growing body of studies that challenge the assumed linear causal pathway of psychosocial attributes on behaviour (such as attitudes or intention), by demonstrating a circular relationship that bicycling itself influences attitudes (Janke and Handy, 2019; Thigpen, 2019). Challenging this linear assumption has important implications for both research and bicycle promotion and encouragement. First, quantitative models assuming a linear relationship will overestimate the effect of attitudes (Kroesen et al., 2017). Second, addressing attitudes through marketing

campaigns may not be as effective as getting people on bicycles through social and physical opportunities (Kroesen et al., 2017; Thigpen, 2019).

By incorporating gender theory, this dissertation has contributed a deeper understanding of the structural issues impacting bicycling mobility. These include habitual performances of safety and precaution in line with gendered socialization, the way that public space is negotiated, and caregiving responsibilities. I have also tried to account for how women's bicycling experiences are shaped not only by gender, but other axes of power and difference. In chapter 4 I show how harassment experiences are shaped by age and racialization, and in chapter 5 I show how bicycling opportunity is shaped by family and settlement status. My work contributes to an emergent body of literature published only in the past few years that consider an intersectional approach to gender and bicycling (McCullough et al., 2019).

My dissertation has been guided by an iterative community-engaged research approach. I collaborated with HUB Cycling (HUB), a bicycling advocacy group, building a trusting and reciprocal relationship with HUB program staff and their community partners. Staff support has been instrumental to the study design and data collection. Further, feedback from HUB staff helped shape my research questions, such as the scoping review question in chapter 2, and discussion with staff provided me insights that informed my preliminary programme theory of change (i.e., hypotheses of how the bicycle skills courses achieved its aims), which I then tested in interviews with participants. Chapter 4 describes some of the components of the programme theory, and a revised programme theory is a forthcoming product. HUB staff members and I together presented research results at two conferences, which helped me identify and develop practice-relevant aspects, so that each chapter discusses implications for policy and practice. Sharing early dissertation findings ensured that research was translated into practice and the community setting immediately.

Finally, this dissertation contributes knowledge to the City of Vancouver about how different parts of its bicycle network are experienced by women at various levels of bicycle engagement. Chapters 4 and 5 illustrate how car-free spaces (i.e., the seawall and Arbutus Greenway) enabled novices and women with children to bike. A certain threshold of skill was necessary to transition to local street bikeways, but the majority of participants who bicycled on streets used local street bikeways heavily. Even the most

experienced bicyclists tended to only divert to regular streets when there weren't other convenient options. Participants in the southeast quadrant of Vancouver, particularly those east of Slocan, had few safe-feeling options for routes heading north or south. The Burrard Street Bridge represented one segment of protected infrastructure where participants encountered rudeness from other riders. Chapter 4 further demonstrates that, in addition to material infrastructure and practical skills, the bicycle culture of Vancouver and how that culture is experienced by new riders is an important characteristic influencing the growth of bicycle mode share. This dissertation identifies areas where planners and advocates can raise etiquette and safety awareness for both new and veteran riders.

6.4. Revisiting the theoretical framework

I used a variety of theoretical approaches in my dissertation. Each theory provided different conceptual tools to consider the research question, for example, using the Behaviour Change Wheel system in chapters 2 and 3 enabled me to describe and compare bicycle course components to other similar interventions. While the Behaviour Change Wheel system was helpful for identifying the missing social or physical opportunity aspects of the course and beyond, it did not aid in thinking about structural processes. In chapters 4 and 5, Social Practice Theory in combination with intersectionality and feminist theories provided a more fruitful lens that enabled me to describe participant experiences and link these to broader social processes, such as access to material resources such as bicycle infrastructure in combination with an expensive housing market or limited childcare options.

Social Practice Theory, with its attention to meanings and norms, helped me identify and reveal how participants reflected on mainstream or standard notions about how bodies should perform in bicycling situations. However, Shove's version of Social Practice Theory offered fewer insights to discuss how normality is constructed and rendered invisible, or the role of gender in social practice (Denegri-Knott et al., 2018; Mechlenborg and Gram-Hanssen, 2020; Walker, 2014). I enhanced the Social Practice framing by integrating scholarship from feminist and intersectional theorists with the three-elements model to reveal: 1) where gender interacted with the acquisition of competence (typically this reflected a participant's individual-level social location); 2) how performances of bicycling associated with masculinity (i.e., speedy) were seen to be

valued more highly; 3) structural disadvantage experienced by participants bicycling with children due to unsupportive bicycling infrastructure.

There were other places where Social Practice Theory provided limited conceptual tools for analysis. For example, participant narratives revealed power relations expressed in interactions with other road users. As bicycling entails moving through space, my dissertation borrowed from feminist spatial thinkers and the notion that space is socially produced. Finally, I drew from other lines of feminist thought to think about the way women take up and move through public space and where this also transferable to the practice of bicycling.

6.5. Limitations

Specific limitations for analyses in chapters 2 to 5 are included within each chapter. This section will comment more generally on some of the limitations of the overall dissertation research. These limitations may be addressed by future research, as discussed below.

I first acknowledge that interview data is a product of the interaction between myself and the study participants. My own background as someone who bicycles, grew up in Canada, has white skin, and is in the privileged position to pursue a PhD likely impacted interviews and information shared by participants. My interview skills and confidence grew over the period of data collection. I became more comfortable with silences, more adept at asking for clarification, and better at asking about gender and other intersecting identities. It is possible that earlier interviews may have produced richer data had I asked more directly about class and racialization, thus improving my intersectional analysis.

Another limitation is that I did not interview men, and could not compare the impact of the course between men and women. It is likely that some of the experiences described by women resonate across gender, especially among people in the process of expanding their bicycling practice. For example, Balkmar (Balkmar, 2018, p. 726) briefly alludes to the femininizing vulnerability of bicycling in traffic: “while control over cars traditionally implies masculinity and power, compared to the motorist, the cyclist’s position tends to parallel femininity, in terms of weakness and being vulnerable.” Other

research suggests that men bicyclists also adopt safekeeping bicycling practices described in chapter 4, such as avoidance, adaptation to motorist behaviour, and avoiding confrontation (Balkmar, 2019). This safekeeping may run contrary to men's bicycling socialization, if they are socialized to engage in riskier bicycling (Scott, 2020), and further research should investigate how courses impact men's bicycling.

One limitation of the questionnaire data used in chapter 3 is that no questions specifically asked about previous bicycling experience. In future, I would include specific questions about previous bicycling experience, such as the last time the participant rode a bicycle. Adding this question would help distinguish between bicycling uptake and increases in bicycling frequency. The interviews also revealed that some of the questionnaire items used for analysis in chapter 3 could be revised in future iterations to better reflect the confidence participants gained in the bicycle skills course.

6.6. Policy implications and future research directions

6.6.1. Policy implications

Each chapter outlined specific implications for policy and practice. I have repeatedly stressed the need for comprehensive packages—bicycle skills training being but one component. Comprehensive packages would enlarge and upgrade the bicycle network so that people of all ages and abilities feel comfortable and safe travelling by bicycle. Findings from chapter 5 stress the need to situate high quality 'all ages all abilities' infrastructure around schools, daycares, community centres, and other places caregivers may need to bicycle with children. Comprehensive packages entail policies to shift away from car dominance, for example, giving people travelling at lower speeds (e.g., foot, bicycle) and using public transport priority over cars, and generally enabling these other modes to travel faster and more directly to destinations than cars. These practical shifts to deprioritize cars will also change social norms around the suitability of bicycles to accomplish many daily tasks, and equitably redistribute responsibility regarding safety across the wider community. Comprehensive packages would also include driver education to share the road with bicyclists. Findings from chapter 4 underscore the need for more training pertaining to bicyclist-automobile interactions to be included in all driver education courses.

A further recommendation is for cities to apply a gender lens to transport and bicycle planning (chapters 4-5). High quality 'all ages all abilities' infrastructure is mentioned in the preceding paragraph, but more can be done with regard to improving infrastructure to address women's comfort, such as improved lighting on-route and where bicycles are parked/stored (Fowler et al., 2017; Lam, 2020; Xie and Spinney, 2018). Studies that have challenged the implicit androcentric bias in the design, implementation, and imagery of urban bicycling make further recommendations beyond my dissertation findings. These recommendations include incorporating diverse women's perspectives into planning and evaluation processes (Lam, 2020; McCullough et al., 2019), and diversifying the representation of bicyclists in policy and promotion documents so that a range of genders, ages, ethnicities, and abilities are prominent (Lam, 2020; Osborne and Grant-Smith, 2017).

I also outlined specific recommendations for improving bicycle skills courses. Findings from chapters 2-4 highlighted the need for follow up support for course trainees. For some, follow up support may include additional on-bike practice sessions (e.g., on traffic-free paths, on different types of bicycling infrastructure, in different neighbourhoods). It may also include sessions on purchasing a bicycle. I endorse the curriculum developed by Bike New York in response to their trainees' needs for structured, progressive on-bicycle practice (personal communication with Rich Conroy April 30). The curriculum entails multiple practice sessions between on-bicycle skill-building instructional courses, with additional workshops addressing buying a bicycle, using bike share, and bicycle commuting (Bike New York, 2020).

6.6.2. Future research directions

There were themes from interview data not fully developed in this dissertation that could provide the basis for future investigation. The first pertains to management of current health concerns through bicycling. Several participants adopted and maintained bicycling due to knee or back injuries. One participant found bicycling easier than walking due to lessened joint strain. Yet storage or bringing bikes on public transit was also an issue for some participants, due to strength required to hoist bicycles up stairs or onto racks. Further study could examine bicycling inclusion through a critical disability lens.

A second finding not developed in this dissertation was the impact of having been struck by a motor vehicle. Three participants described experiences of having been hit by a car while riding, which affected their confidence and willingness to bicycle around motor traffic. They saw the bicycle skills course as a means to regain and repair confidence, similar to Bissell's (2018) notion of "repair work"—a temporary cautious bicycling style adopted by bold bicyclists who experience a near miss. Future research could investigate the impact of collisions on future bicycling.

A third undeveloped finding pertained to the sense of belonging participants developed by taking up bicycling. Several participants reported that bicycling enabled them to see and experience their neighbours and neighbourhoods in new ways, which fostered a sense of neighbourhood connectedness. Furthermore, some participants were aware of Vancouver's Greenest City 2020 Action Plan, and stated that taking up bicycling enabled them to participate in the Greenest City vision, enhancing their sense of civic belonging. More study in this area could distill what (belonging) can be attributed to bicycling specifically, versus walking. More study could also investigate how belonging and bicycling is interwoven with ethnicity, settlement status, and symbolic capital associated with bicycling.

As mentioned in section 6.4, I did not interview men in this dissertation, yet there remains a gap in our knowledge about how bicycle skills training impacts men's bicycling. Women disproportionately make up bicycling courses, and it would be useful to understand if and why courses are unappealing to men.

6.7. Concluding thoughts

The interdisciplinary research outlined in this dissertation weaves together behaviour change theory and gender to examine the impact of an individual level intervention (a bicycle skills course) on encouraging bicycling. It finds that more systemic approaches are needed to increase bicycling participation. However, for a subset of diverse women participants, the bicycle skills course provided a safe environment to improve bicycle handling skill, learn traffic rules and safety, put knowledge into practice, and reinforce the knowledge they already had. For many participants, the course enabled them to bicycle in a greater variety of conditions, thus enhancing their bicycling mobility. Bicycle skills training can be important to ensure that everyone has access to

acquire a baseline level of bicycling skill, and courses can also clarify norms and etiquette.

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Appendix A.

Questionnaire items

These were the questions included across 4 surveys. Not all questions were included on all surveys. The questions are marked as follows:
T1=administered before intervention; T2=administered 1 month follow up; T3=administered 3 months follow up; T4=administered 12 months follow up.

TRAVEL BEHAVIOUR

Q1 (T1, T2, T3, T4) Do you have a bicycle, or have access to a bicycle?
- Yes
- No

If selected yes, then filter to following 2 questions:
Q2 (T1, T2, T3, T4) Do you have access to a bicycle helmet?
- Yes
- No

Q3 (T1, T2, T3, T4) Do you have access to a bicycle lock?
- Yes
- No

Q4 (T1, T2, T3, T4) Have you ever used a public bike share bicycle in Vancouver (i.e., Mobi?)
- Never
- Once – few times per year
- Once per month
- Once per week
- More than once per week

Q5 (T1, T2, T3, T4) In the past month, how often have you ridden a bicycle to get to work or school?

- Less than once per month
- One to three times per month
- Once per week
- 2-3 days per week
- 4-5 days per week
- 6-7 days per week
- Never - I do not ride a bicycle to work or school
- N/A (do not have a workplace or school)

If selected cycling of any duration, then filter to following question:

Q6 (T1, T2, T3, T4) What is the average time of your one-way journey when you travel by bicycle to get to work or school?

- Less than 14 minutes (0-14 minutes)
- 15-29 minutes
- 30-44 minutes
- More than 45 minutes
- Don't know

Q7 (T1, T2, T3, T4) In the past month, how often have you ridden a bicycle for errands or shopping?

- Less than once per month
- One to three times per month
- Once per week
- 2-3 days per week
- 4-5 days per week
- 6-7 days per week
- Never - I do not ride a bicycle to do errands or shopping

If selected cycling of any duration, then filter to following question:

Q8 (T1, T2, T3, T4) What is the average time of your one-way journey when you travel by bicycle for errands or shopping?

- Less than 14 minutes (0-14 minutes)
- 15-29 minutes
- 30-44 minutes
- More than 45 minutes
- Don't know

Q9 (T1, T2, T3, T4) In the past month, how often have you ridden a bicycle outdoors for fun or exercise?

- Less than once per month
- One to three times per month
- Once per week
- 2-3 days per week
- 4-5 days per week
- 6-7 days per week
- Never - I do not ride a bicycle for fun or exercise

If selected cycling of any duration, then filter to following question:

Q10 (T1, T2, T3, T4) On average, how long is your ride (in minutes) when you bicycle for fun or exercise?

_____

Q11-17 (T1, T2, T3, T4) In a typical week, how many days per week do you use the following modes of transportation?

	Every day or almost every day (6-7 days)	Most days (4-5 days)	Some days (1-3 days)	Never
Bus/skytrain				
Walk				
Taxi				
Get a ride with someone				
Drive a car				
Bicycle				
Other				

Q18-21 ***(*T1, T2, T3, T4*)*** *ABILITY TO BICYCLE (RELATED TO COURSE OBJECTIVES)*

For the questions below, please indicate how much you agree with the following statements. You may choose not to answer.

How much do you agree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Choose not to answer
I know how to ride a bicycle (i.e., balance, steer, stop)						
I feel I can ride a bicycle safely on a street with cars						
I feel I can ride a bicycle safely on a path away from traffic						
I feel I can use a map to choose a suitable route for me to cycle						

Q22-23 ***(*T1, T2, T3, T4*)*** *PERCEPTIONS OF CYCLING*

How much do you agree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Choose not to answer
It is safe to bike in in my neighbourhood						
Cycling is a fast and convenient way to get around my neighbourhood						

Q24-29 *(***T1, T2, T3, T4***) PERCEIVED CONTROL*

How much do you agree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Choose not to answer
For me to ride a bicycle for daily travel would be easy						
I know where safe bike routes are						
Many of the places I need to get to regularly are within bicycling distance of my home						
I can travel by bicycle when I have things to carry						
I can travel by bicycle in rainy weather						
I can travel by bicycle when I have children with me						

Q30-35 *(***T1, T2, T3, T4***) ATTITUDES*

How much do you agree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Choose not to answer
I like riding a bike						
I prefer to bike rather than drive whenever possible						
Cycling can sometimes be easier for me than driving						
I prefer to bike rather than take transit whenever possible						
Cycling can sometimes be easier for me than taking transit						

Q35-41 *(***T1, T2, T3, T4***) NORMS*

How much do you agree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Choose not to answer
My friends and family members ride bicycles						
People from my culture or community ride bicycles						
Women from my culture or community ride bicycles						
People I admire ride bicycles						
There are not many cyclists in my neighbourhood						

Most people who are important to me, for example my family and friends, think I should bike more						
Many of my family, friends, and co-workers ride a bike to get to places (such as work, or for errands and shopping)						

SOCIAL SUPPORT

Q42 (T3, T4) Are you a member of a bicycle meetup, bicycle club, or other bicycle group?

- ○ Yes
- ○ No

Q43-46 (T3, T4) In the past 3 (12) months:

	Always	Often	Sometimes	Rarely	Never	Choose not to answer
How often have any family members encouraged you to ride a bicycle?						
How often have any family members bicycled with you?						
How often have any friends, acquaintances, or co-workers encouraged you to ride a bicycle?						
How often have any friends, acquaintances, or co-workers bicycled with you?						

Q48 *(T2, T3, T4) FURTHER TRAINING*

Since your initial course with HUB last summer, have you taken any further formal cycling training?

- ○ No
- ○ Yes. Please describe: _____

DEMOGRAPHICS

Q49 (T1) What is your gender:

- ○ Male
- ○ Female
- ○ Identify as something other than male/female: _____

Q50 (T1) What is your age?

- ○ Between 19 and 29 years
- ○ Between 30 and 39 years
- ○ Between 40 and 49 years
- ○ Between 50 and 59 years
- ○ Between 60 and 69 years
- ○ 70 years or older

Q51 (T1) Are you:

- ○ Aboriginal
- ○ Arab
- ○ Black
- ○ Chinese
- ○ Filipino
- ○ Korean
- ○ Japanese
- ○ Latin or South American
- ○ South Asian (e.g., Indian, Pakistani, Sri Lankan, etc)
- ○ Southeast Asian (e.g., Vietnamese, Cambodian, Laotian, Thai, etc)
- ○ West Asian (e.g., Afghan, Persian, Turkish, etc)
- ○ White
- ○ Something else, or mixed identity from two or more groups (please describe):_____

Q52 (T1) What country were you born in? **_____**

Q53 (T1) How many years have you been in Canada?

- ○ Less than 1 year
- ○ 1-2 years
- ○ 2-3 years
- ○ 3-5 years
- ○ 5-10 years
- ○ 10-20 years
- ○ More than 20 years

Q54 (T1) Do you currently have a valid driver's license?

- ○ Yes
- ○ No

Q55 (T1, T2, T3, T4) Do you have, or have access to a motor vehicle (including car, truck, motorcycle)?

- ○ Yes
- ○ No

Q56 (T1, T2, T3, T4) How many children or youth aged 17 AND UNDER live in your household?-

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5 or more

Q57 (T1, T2, T3, T4) Are you currently employed?

- ○ Full-time
- ○ Part-time
- ○ Not currently employed

Q58 (T1, T2, T3, T4) Are you currently a student?

- ○ Full-time
- ○ Part-time
- ○ Not attending school

Q59 (T1) What is the highest level of education you have completed?

- ○ Some high school or less
- ○ Graduated high school
- ○ Vocational/college/technical
- ○ Some university
- ○ Graduated university
- ○ Other: _____
- ○ Don't know

Q60 (T1) Which of the following best describes your total household income before taxes in 2016?

- ○ Under $20,000
- ○ Between $20,000 and $49,999
- ○ Between $50,000 and $99,999
- ○ Between $100,000 and $149,999
- ○ Over $150,000
- ○ Don't know
- ○ Prefer not to say

Q61 (T1, T2, T3, T4) What is your postal code where you live? _____

Appendix B.

Questionnaire protocol

SFU SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

Increasing Cycling for Transportation in Canadian Communities: Understanding what works
Study protocol guidelines

TITLE OF STUDY:
Increasing Cycling for Transportation in Canadian Communities: Understanding what works

NAME OF PI:
This is a multi-site, multi-jurisdictional study. Dr. Meghan Winters, Faculty of Health Sciences, is the PI for the SFU-led portion of the research and this research ethics board approved application.

COLLABORATORS:
Dr Beth Savan is the PI of the SSHRC grant and PI on the University of Toronto ethics application.

BACKGROUND:
The goal of this study is to understand the impact of behavioral interventions for cycling in BC and Ontario suburbs on cycling uptake. This research will involve partnerships with community partners who offer cycling training programs. The SFU-led research pertains to the study of behavioral interventions in Metro Vancouver, in parallel to the activities in the Greater Toronto Area led by Dr. Savan. The SFU protocol is analogous to that outlined in the U of T ethics application, with the following nuances:

PERSONNEL:
- The SFU research team for our proposed study is comprised of Dr. Meghan Winters and Ms. Stephanie Sersli, a research assistant who will begin in the doctoral program at the Faculty of Health Sciences at SFU in Sept 2015, and who will use this data as part of her doctoral thesis.

INTERVENTION:
- The community partner offering the cycling education courses in Metro Vancouver is HUB Cycling, the leading cycling action organization in Metro Vancouver (> 1,500 members and 25,000 direct contacts), delivering cycling education programs across urban and suburban centres to enable active transportation and improve mobility options.
- The HUB cycling education programs are typically 1 or 2-day courses with a classroom-based and a practice-based component. Participants sign a waiver in advance of participation of the course. The interventions under study in the Toronto arm are longer programs (several months).

STUDY PROTOCOL:
- The SFU-based study will use a modified questionnaire, given the different scope of the intervention offered by HUB Cycling. Current drafts of the survey question are included in this application:
    - Questionnaires will be completed before the course, and again at 1 month after the course, 3 months after the course, and 12 months after the course
    - The questionnaires will be self-administered web-based surveys
    - A link to the questionnaires will be sent to study participants via email.
- The SFU-based study will offer incentives for completing follow-up surveys, providing a $10 gift card (their choice of Tim Horton's, Safeway, or iTunes) at completion of each survey.

- To maintain participant engagement (due to the lengthy interim period between 3 month and 12 month post-course follow up questionnaires), participants will be emailed a short research update.
- Eligibility will be restricted to English speaking adults (>19 years) (no translation of surveys, as may be done in Toronto).
- We will recruit study participants from the pool of individuals registered in the HUB Cycling courses, which are advertised and promoted by the community partner and related organizations.
    - We will create a comparison group consisting of individuals who do not participate in a HUB Cycling course. These study participants will be recruited from the same host community organizations as in the point above.
    - In person recruitment for course participants and comparison group participants will take place upon invitation from the host community organizations.
    - Consent forms for both potential intervention participants and comparison group participants will be distributed at time of recruitment. Participants have the option of returning their consent form immediately or at a later point to the research assistant.
    - Reminder consent forms will be sent to intervention participants alongside HUB's course waivers, via email approximately one week before the course.
    - For cycling courses where HUB registers participants exclusively online, we will recruit potential comparison group participants from the pool of people who register but do not attend the course. For these potential participants, recruitment will be via email. A link to the PDF version of the comparison group consent form and baseline questionnaire will be included in this email.
- We will use a 2-step consent process before administering baseline surveys to ensure each participant has had a chance to review the consent form:
    - Paper-based study information letters and consent forms will be distributed at the time of in-person recruitment, and again at the time of the course
    - Those who are not able to return a paper consent form (e.g., they lose or forget to bring it) will be able to consent on the preface of the questionnaire.
    - All participants will be asked to provide electronic consent before accessing the baseline questionnaire:
        - Study information will preface the questionnaire
        - An explicit consent question must be checked to access the questionnaire contents
        - A link to a printable PDF version of the study information letter will accompany each emailed survey link.

CONFIDENTIALITY**:**

- We will apply the same management of personal information: personal and contact information for participants will be removed and replaced with a study ID number to track participants. For SFU, the information linking a participant to their study ID number will be stored in a password protected file on a password protected SFU-based computer. Only the PI and research assistant Sersli will have access to this linking file.
- Any physical copies of surveys for the SFU-led aspect of this work will be stored in a locked drawer in a secure area in the Faculty of Health Sciences at SFU. Full copies of the survey will be

retained for up to 5 years (3 in as per University of Toronto protocol), while the study ID-based file (no name or specific address) will be retained (as per University of Toronto protocol).

- Fluid Surveys will be used for all web-based surveys, and appropriate wording has been added to the SFU consent form.

Appendix C.

Interview schedule

Introductory text

Today I'll start by asking general questions about the role of bicycling in your life, and then I'll move on to some more specific questions about your bicycling these days. It has been a while since your bicycle course and your last questionnaire, so some things might have changed for you. It is fine if you aren't riding your bike these days. I'm interested in hearing your experiences even if you aren't riding your bike. You can choose to skip any questions you don't want to discuss, and you can end the interview at any time.

I'll be taping today's interview, and writing up the transcription of our conversation. Then the recording is destroyed. The only people who ever see your transcript will be me, and other people on the research team. Your name will not be on the transcript. Any other names you give me, or the names of any places you describe will be removed from quotes or data summaries that might be used for academic papers or publications.

Do you have any questions for me before we get started?

Bicycling experience

Q1 Tell me about the role of bicycling in your life, starting with when you first began riding a bike

Possible probes:

- Did you ride a bicycle as a child or teen?
- [For respondents in Canada <5 years]: Tell me about any bicycling you did before you came to Canada
- What was happening in your life when you stopped bicycling/started bicycling again?

Q2 (For participants who disclose they no longer have a bike) What are your challenges in finding/getting a bike?

Trip purpose, facilitators & barriers

Q3 Tell me about your bicycling in an average week

Possible probes:

- Where do you go by bike in a typical week?
- What makes it convenient or difficult for you to get by bike to places you need to go?

Let's talk (more) about bicycling to work or school. I'll start with a very specific question.

Q4 How often would you say that you rode a bike to get to work or school in the past month?

- *0 times*
- *1-3 times*
- *Once per week*
- *More than once per week*
- *Never ride a bike to work or school*
- *Don't have a workplace or school*

Q5 [For non commuters]: Are you able to, or are you interested in biking to work or school?

[For bike commuters]:Why do you bike to work/school?

Q6 [For bike commuters]: Could you bike to work more than you do now, if you wanted to?

Q7 [For bike commuters]: Tell me about your preferred route to work/school.

Q8 [For everyone]: What makes it difficult (or convenient) for you to ride to work/school?

Possible probes:

- What kind of job do you have? Is it a type of job that is suitable for riding to work?

Let's talk (more) about bicycling to run errands, do your shopping, or otherwise get to places to do things. Again, I'll start with a very specific question.

Q9 How often would you say that you rode a bike to run errands, shop, or visit friends in the past month?

- *0 times*
- *1-3 times*
- *Once per week*
- *More than once per week*
- *Never ride a bike to run errands, shop, or visit friends*

Q10 [For non errand bicyclists]: Are you able to, or are you interested using your bike to shop or run errands or visit friends?

Possible probes:

- How many people in your house do you shop for? How many times/week? By car or foot?
- Who is generally responsible for doing the grocery shopping in your house?

[For errand bicyclists]: Tell me more about biking for errands, shopping, or visiting friends.

Possible probes:

- Tell me about your preferred routes

Q11 [For everyone]: What makes it difficult (or convenient) for you to bike for errands, shopping, or visiting friends?

Let's talk (more) about bicycling you do for fun or exercise (leisure). Again, I'll start with a very specific question.

Q12 How often would you say that you rode a bike for fun or exercise in the past month?

- *0 times*
- *1-3 times*
- *Once per week*
- *More than once per week*
- *Never ride a bike for fun or exercise*

Q13 Where do you go? How do you decide where to go?

Possible probes:

- Who do you go with?
- How do you get there?

Q14 Some people choose to use bicycles for exercise, or as part of a fitness routine. Where does bicycling fit in with any fitness goals/routine you may have?

Social support

Q15 Tell me about people in your life who support you to bike

Possible probes:

- Are there people you ride bikes with? Friends? Family members? Kids?
- Did you attend the HUB bike course with someone? Tell me about that

Q16 [For participants with children]: Tell me about bicycling with your kids

Possible probes:

- How many and how old are they?
- Where do you go when you bicycle with them?
- What routes do you prefer?

Q17 [For participants with children]: How does bicycling reflect the things and/or values you need or want to do as a parent and mother?"

Possible probes:

- Would you say that bicycling is relevant?

Q18 [For participants with children]: Some research has suggested that household responsibilities, or caring responsibilities (like caring for children or elders) impacts how, when, and where we ride bicycles. How does this theory fit with your own bicycling experience?

Q19 [For participants with children who say they feel unsafe/unwilling to bike with their kids]: What would help you to feel safe transporting your child by bicycle?

Bicycle course

Q20 Thinking back to your HUB bicycling course, why did you register in the course?

Possible probe:

- Do you remember how you found out about the HUB course?

Q21 Thinking back to what happened during your HUB bicycling course, what do you think was the most helpful for your bicycling?

Possible probes:

- Tell me about there any "aha!" moment where something suddenly made sense?
- Did the HUB course provide opportunities for you to learn from other people, practice new skills, feel braver or more confident? Tell me more about your experience [if you can remember]
    - And what happened after the course? Did you continue to [feel this way?]

Q22 What did you want to achieve from taking the HUB bike course?

Possible probes:

- Were you hoping to increase your bicycling?
- How did the course help you achieve that (either during course or afterward?)
- What was still missing for you? (Can be something outside of scope of HUB course)

Q23 How have your thoughts and feelings about bicycling changed over the year since the bicycling course?

Q24 What does 'bicycling confidence' look like for you?

Q25 Some interview participants have suggested other cyclists affect their bicycling. Has that been your experience?

Other outcomes

We've talked a little bit about how bicycling helps you get to places and how bicycling helps your practical needs. I want to hear a bit more about other roles bicycling plays in your life.

Q26 Why is bicycling important to you [in Canada]?

- Tell me more about [answer]. Was this something that was missing from your life before?

Identities

I'd like to hear your thoughts on gender and bicycling.

Q27 Would you say that gender is relevant to bicycling? How (not)?

Possible probes:

- How do you think that being a women has affected your bicycling experiences or decisions?
- Do you think Vancouver is an easier or harder place to ride a bicycle as a woman than other places you've lived? Why?

We've been talking about gender as one part of identity, and I wanted to open the space to talk about other aspects of identity, culture, or community. Some people think about "culture" as their ethnic identity, but today "culture" can mean anything you want it to mean. Community can also mean anything you want it to mean, for example, it can be your circle of friends, your cultural or peer community or even your work community. You get to define it.

Q28 How have other aspects of your identity/background affected your bicycling experiences or decisions?

Possible probes:

- How would you describe your community's attitudes toward bicycling?
- Do you see differences or similarities in your bicycling compared to other [friends/community]?
- Earlier you mentioned [subject]. Can you tell me more about this?

Q29 Is there anything else you would like to tell me, or that you think I should know?

Appendix D.

Interview protocol

Getting from here to there: boosting women's bicycling inclusion through bicycle skills training
Study details

Introduction

PROJECT TITLE:
Getting from here to there: boosting women's bicycling inclusion through bicycle skills training

NAME OF PRINCIPAL INVESTIGATOR:
This study is led by Stephanie Sersli, a PhD student in the Faculty of Health Sciences, SFU.

COLLABORATORS & RELATIONSHIP WITH PREVIOUSLY APPROVED STUDIES:
Ms. Sersli is supervised by Dr. Meghan Winters in the Faculty of Health Sciences. Her other collaborators are members of her doctoral committee: Dr. Maya Gislason in the Faculty of Health Sciences and Dr. Nicholas Scott in the Department of Sociology and Anthropology. Please note that this study led by Ms. Sersli is nested within a multi-site, multi-jurisdictional study funded by SSHRC entitled "*Increasing cycling for transportation in Canadian communities: understanding what works*". Dr. Meghan Winters is the PI for the SFU-led portion of the *Increasing cycling* project, and the SFU ORE study reference is 2015s0220. The PI of the overall project and named on the SSHRC grant and University of Toronto ethics application is Dr. Beth Savan from the University of Toronto.

FUNDING SOURCE:
Ms. Sersli holds a SSHRC doctoral award (2017-2020). Project-related costs, such as participant incentives, will be covered from the SSHRC funding for "*Increasing cycling for transportation in Canadian communities: understanding what works*".

Summary of proposed research

BACKGROUND & STUDY PURPOSE:
The goal of the *Increasing cycling for transportation in Canadian communities: understanding what works* study is to understand the impact of behavioral interventions in BC and Ontario on bicycling uptake. The SFU-led research pertains to the study of behavioral interventions in Metro Vancouver. The intervention under study is a bicycle education program delivered by HUB Cycling, a bicycling advocacy organization in Metro Vancouver. Dr. Winters study recruited adult participants from HUB's bicycle education program to complete four questionnaires over a 12 month period. Ms. Sersli has been a research assistant on this project 2015-2017.

Ms. Sersli's research is a complement to this. Ms. Sersli will examine how bicycle skills training encourages participation of new and returning female bicyclists. This research is to respond to the documented gender gap in bicycling: statistics from most North American, British, and Australian cities indicate that 2/3 of bicycling trips are made by men. Ms. Sersli will investigate the impact bicycle skills training has on bicycling uptake, as well as identify the process and contexts that enable bicycling uptake for women. She will do this by recruiting and interviewing a subset (n=30) of female participants from Dr. Winters study.

RESEARCH QUESTIONS:

1. What facilitates and sustains women's bicycling commuting after participating in bicycle skills training? How do bicycle commuting strategies and resources differ for women with children?

2. How does leisure bicycling encourage a greater propensity for women's transportation bicycling after taking bicycle skills training?
3. How do women accomplish leisure and errand bicycling: where do they go by bicycle, how do they get there, and who travels with them?

DATA ANALYSIS PLAN:
Interview data will be analysed using interpretive description (Thorne, 2008). Interpretive description is heavily influenced by grounded theory, and some have argued that it should be considered a variation of grounded theory (Berterö, 2015).

Research procedures and methods

PROSPECTIVE PARTICIPANT INFORMATION:
The Vancouver-based arm of the "*Increasing cycling for transportation in Canadian communities: understanding what works*"" project under Dr. Winters enrolled adults registered in a bicycle skills training course in 2015-2017. Course participants included people new to bicycling as well as people seeking further proficiency in street riding; a range of ages and ethnicities; and a range of settlement/acculturation experiences (newcomers in Canada less than 5 years, people who have lived in Canada for 5+ years, and those born in Canada). Only those aged 19 and over, and with basic English reading skill were eligible to take part in the study, and 297 people were recruited.

PARTICIPANT RECRUITMENT, CONSENT, PARTICIPANT INCENTIVES
Ms. Sersli's project involves recruiting and interviewing a subset of 30 women from 2015, 2016, and 2017 participants. She has been a research assistant for the "*Increasing cycling for transportation in Canadian communities: understanding what works*" project where her role was recruiting participants, following up with participants during their study period, and analyzing questionnaire data. Thus she has direct access to contact information. Prospective interview participants will be identified using questionnaire results according to two criteria:

- First, recruitment will be restricted to questionnaire respondents who indicated interest in participating in follow up studies, n=258. There was an item on questionnaire where participants granted permission to be contacted for follow up study requests.
- Second, the questionnaires are analyzed to show bicycling uptake. Ms. Sersli proposes to identify female participants who increased bicycling frequency from baseline. These women will form the target recruitment group for interviews.

Potential interview participants will be then contacted via email (Appendix 1) and invited to one-on-one semi-structured interviews, conducted by Ms. Sersli. A study information letter will be included in the email. If women agree to be interviewed, the same study letter and consent form will be provided and collected at the time of interview. The study letter and consent form are attached (Appendix 2).

All data will be collected in Metro Vancouver, Canada. Interviews will be conducted in a public place (e.g., library) convenient to the participant, expected to last 60-90 minutes. The interview schedule is in Appendix 3; note that maps may be used to provide an aid to discussion. In the unlikely event no public place can be arranged, Ms. Sersli will interview women in their homes. If necessary, follow-up interviews will be arranged. An honorarium of $20 CAN per interview will be provided to participants. Childcare costs up to $20 may be available as needed.

POTENTIAL RISKS
There are no anticipated risks to participants. Some participants may feel uncomfortable discussing identity. Participants will be reminded at the start of the interview they can choose to not answer questions.

As for risk for research assistant, in the event Ms. Sersli interviews women in their homes, she will carry a mobile phone and pre-arrange a scheduled check-in call once the interview is complete with Dr. Winters. She will let the interviewee know that a pre-arranged phone call has been scheduled for the end of interview.

CONFIDENTIALITY MEASURES, DATA ACCESS, RETENTION & DESTRUCTION
Personal and contact information for participants will be removed and replaced with a study ID number. The information linking a participant to their study ID number will be stored in a password-protected file on SFU Vault. Only Ms. Sersli will have access to this linking file. All consent forms containing participant names will be stored in a locked drawer in a secure area in the Faculty of Health Sciences at SFU.

Interviews will be audio-recorded and transcribed verbatim by a professional transcription service (Online & Ontime, https://www.onlineandontime.com/FAQ.htm). A confidentiality agreement will be signed by this transcription service, and the study ID number will be used to reference audio files and transcripts. Audio files will be destroyed after transcription. These raw transcripts will be stored as password-protected files on SFU Vault and retained for up to 7 years. Transcripts will be de-identified, and only de-identified transcripts will be made available for use by others via a data user agreement within the SSHRC-suggested period (i.e., within two years of project completion).

Maps will be used to complement interviews. Study ID numbers will be used to link interview transcripts and participant maps. Maps will be stored as paper hardcopies in a locked drawer in a secure area in the Faculty of Health Sciences at SFU, and retained for up to 7 years.

Only Ms. Sersli, Dr. Winters, Dr. Scott, and Dr. Gislason will have access to the original raw transcripts and maps. In any presentation of data analysis findings and in use of quotes, identifying information such as names of work places or membership in clubs will be removed. No participant maps will be used in presentation of data analysis.

After 7 years, identifiable data in digital format (information linking a participant to her study number, raw transcripts) will be destroyed, and all paper hardcopies (consent forms, maps) will be cross-shredded.

References

Berterö, C., 2015. Developing qualitative methods - or “same old wine in a new bottle.” Int. J. Qual. Stud. Health Well-being 10, 10.3402/qhw.v10.27679. doi:10.3402/qhw.v10.27679

Thorne, S., 2008. Interpretive description. Left Coast Press, Walnut Creek, CA.

Appendix E.

Interview field notes template

Interview field notes (to be completed within one hour of interview)
[Participant code]
[Date of interview, time of interview start & end]
[Interview location]

Setting
- [notes]

General interview recap
- [notes]

Notes/thoughts on body language, discussion climate, general interview tone
- [notes]

What worked well in this interview (or, what did I try to do differently this time)?
- [notes]

Improvements I'd like to make for next time
- [notes]

What surprised me about this interview?
- [notes]

Where was I judgmental?
- [notes]

Quick thoughts: how does what participant said today differs from/confirms what was said in earlier interviews?
- [notes]

Appendix F.

Supplementary table to chapter 3

Negative binomial random intercept models (adjusted*) on impact of a bicycle skills training course for bicycling frequency (days per month) at 1, 3, and 12 months from baseline

	Commute	Errands	Leisure
	Rate ratio (95% CI)	Rate ratio (95% CI)	Rate ratio (95% CI)
Time			
T1 (baseline) REF	1.00	1.00	1.00
T2 (1 month)	0.79 (0.50–1.22)	0.76 (0.45–1.27)	0.87 (0.56–1.36)
T3 (3 month)	0.50 (0.30–0.84)	0.74 (0.43–1.26)	0.45 (0.26–0.77)
T4 (12 month)	0.66 (0.42–1.05)	1.21 (0.75–1.95)	1.28 (0.85–1.92)
Treatment			
None (comparison) REF	1.00	1.00	1.00
course	0.76 (0.31–1.86)	1.21 (0.56–2.65)	1.25 (0.76–2.07)
Interactions			
baseline x comparison REF	1.00	1.00	1.00
T2 x course	1.58 (0.95–2.62)	1.57 (0.89–2.76)	1.46 (0.90–2.35)
T3 x course	2.03 (1.14–3.59)	1.49 (0.83–2.68)	1.91 (1.07–3.41)
T4 x course	1.76 (1.04–2.97)	0.85 (0.50–1.45)	0.84 (0.53–1.32)

* Models adjust for gender, city of residence, season, and age.